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FINAL REPORT D-51001
DEVELOPMENT OF COMPONENTS FOR AN
S-BAND PHASED ARRAY ANTENNA SUBSYSTEM

Prepared for:

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Space Administration
Lyndon B. Johnson Space Center
Houston, Texas

Contract No. NAS9-14485

...S SUBJECT TO CHANGE

Prepared by:

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Dallas, Texas 75222
October 1975

TEXAS INSTRUMENTS
INCORPORATED

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ACKNOWLEDGEMENTS

This final report describes the results of a design-development effort performed by Texas Instruments for NASA/Lyndon B. Johnson Space Center under Contract NAS9-14485. Texas Instruments appreciates the opportunity to have performed this contract, and hopes NASA finds the information in this report complete and useful.

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The assistance of Dr. Dean Cubley and Mark D. Walton (NASA technical monitor) of the JSC Electromagnetic Systems Branch is gratefully acknowledged. Their constructive comments and technical advice have been very helpful in this program.

Texas Instruments will welcome the opportunity to expand the technical foundation prepared by this effort. We are confident that continued development of the spacecraft antenna array described herein will lead to a useful subsystem applicable to several spacecraft uses.

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SECTION I

INTRODUCTION

This report contains the results of the second phase of the S-Band Antenna Phased Array Communications System (SPACS II) program sponsored by the Electromagnetic Systems Branch of NASA Lyndon B. Johnson Space Center under contract NAS9-14485. The system requirements, module test data, and S-band phased array subsystem test data will be discussed in this report.

Many instances of spacecraft-to-spacecraft communications (e.g., spacecraft/relay satellite and shuttle/payload) may require a medium amount of antenna gain for successful implementation. Of the two approaches to achieving antenna gain (i.e., mechanically steered reflector or electronically steered phased array), the phased array approach offers the greatest simplicity and lowest cost (size, weight, power, and dollars) for this medium gain. This report describes a competitive system design as well as hardware evaluation which will lead to timely availability of this technology for implementing such a system.

The objectives of the SPACS II contract are:

To ' ·bricate and test six engineering model transmit/receive microelectronics modules.

To design, fabricate, and test one dc and logic multilayer manifold.

To integrate and test an S-band phased array antenna subsystem composed of antenna elements, seven T/R modules, RF manifolds and dc manifold.

The developmental requirements under this contract consisted of fabricating and testing five additional T/R modules identical to those developed under NASA contract NAS9-14196 with Johnson Space Center, developing and testing one T/R module similar to the five above but with an additional L-band capability, designing and testing a dc and logic multilayer manifold for use with these modules, integrating all the hardware developed under NAS9-14196 and this contract (NAS9-14485) into an S-band phased array antenna subsystem, and testing this subsystem.

SECTION II

ANTENNA ARRAY SUBSYSTEM REQUIREMENTS

The antenna array subsystem requirements are based upon the set of system parameters outlined in Table 2-1. These requirements are closely keyed to using the existing technology developed under NASA Contract NAS8-25847 with MSFC. The system parameters have been updated several times during the course of this contract to reflect current JSC design requirements.

The system configuration envisions placement of at least four antenna arrays approximately 10.68 inches in diameter mounted on the spacecraft as shown in Figure 2-1.

A basic system block diagram is shown in Figure 2-2. To minimize the interface and most easily compliment the radio systems and onboard computer, the RF and computer signals and dc power will feed this system from a central point. (A configuration alternative might use multiple-point interface for redundancy at the expense of weight, power, and cost.) The radio system interface consists of a nominal transmitter input of +29 dBm at S-band and a receive output which feeds a transponder with a noise figure less than 8 dB. As noted in Table 2-1, the receive system also operates at L-band, but with degraded noise figure and gain.

Table 2-1. System Design Parameters

Transmit frequencies	2217.5 and 2287.5 MHz
Transmit EIRP (on boresight)	24 dBw
Transmit EIRP (scan angles)[1]	18 dBw
Array transmit power input	30 dBm maximum; 28 dBm minimum
Receiver frequencies: S-band[2]	2041.9 and 2106.4 MHz
L-band	1775.5 and 1831.8 MHz
Receive noise temperature[3]	600°K (design goal) and 700°K (maximum)
Receive antenna gain (on boresight)	11.5 dB
Receive antenna gain (60-degree scan)	5.5 dB
Antenna beamwidth (on boresight)	40° (nominal)
Array receive electronic gain S-band	20 dB
Array diameter	10.68 inches (main body)
Coverage	Maximized for four arrays on a 200-inch cylinder
Array thickness (including array steering controller but not power supply)	6 inches
Weight (four-array system less cables)	50 pounds (four arrays)
DC power (one array including controller)	130 watts
Steering angle commands (two)	8 bits each (maximum)
Phase variation	±12°
Amplitude variation	±0.7 dB
Phasing time	0.2 μs
Normal TPS bondline temperature near faceplate in front of antenna	-185° to +350°F
Surface curvature	Flat antenna aperture

[1] 70- by 50-degree elliptical scan with 70-degree scan along X-axis.

[2] With ±11-MHz spread spectrum at each S-band receive frequency.

[3] Degraded performance acceptable at L-band receive frequencies.

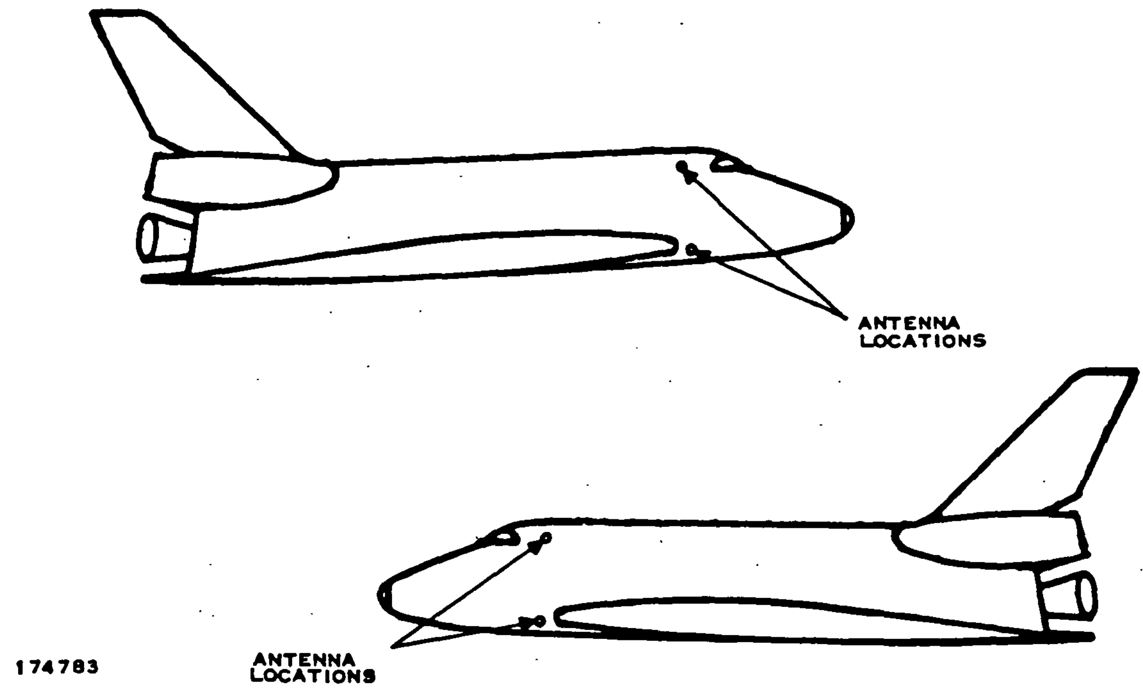


Figure 2-1. Antenna Locations

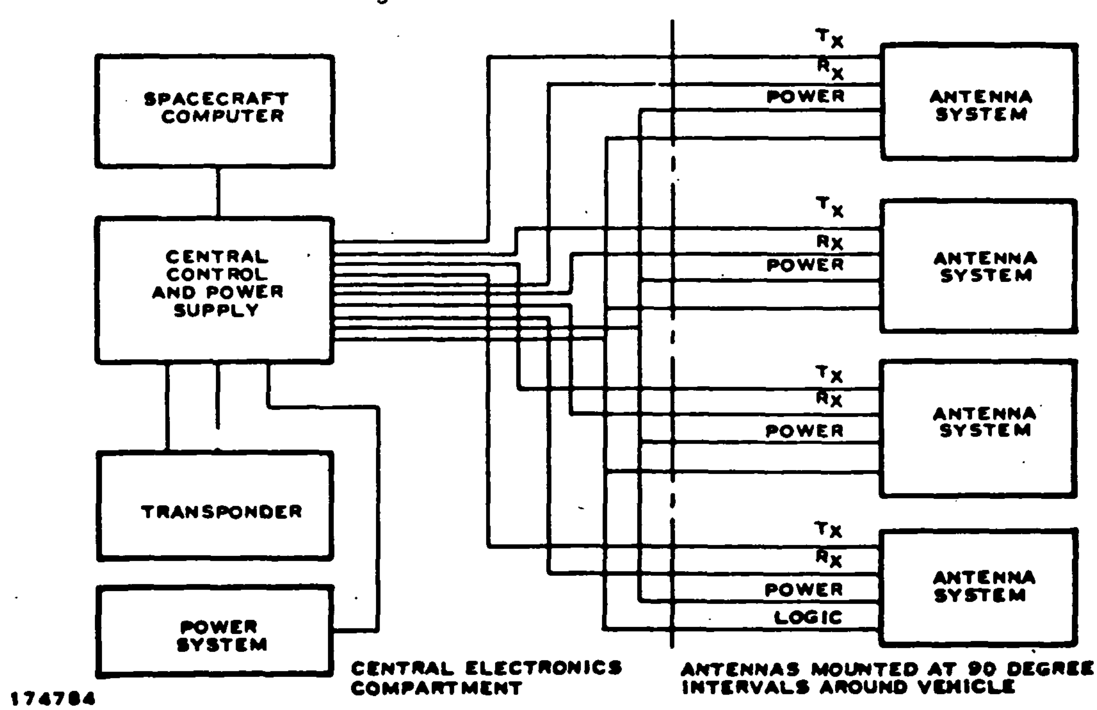


Figure 2-2. System Concept, Central Control

SECTION III

T/R MODULE DESIGN AND EVALUATION

A. OUTER MODULE (P/N SK 784010-1) EVALUATION

The five additional T/R modules for the outer rows of antenna elements were the same design and construction as the module developed under NASA Contract NAS9-14196 for JSC. Figures 3-1, 3-2, and 3-3 are photographs of this module, which is composed of 3-bit switched line transmitter and receiver phase shifters, a three-stage transmitter power amplifier, a transmitter ferrite isolator, an MIC transmitter edge-coupled filter, a three-port ferrite circulator duplexer, a receiver combline filter, and a receiver three-stage low-noise amplifier.

The specifications and test procedures for the T/R modules developed under this contract are given in Texas Instruments drawing number SKDD 301 (Appendix A of this report). The individual outer module test data for the five outer modules (MSN 003, 004, 005, 006, and 007) built under this contract are given in drawing number SKDD 302 (Appendix B). Also included is the SPACS I outer module (MSN 001 built under NASA Contract NAS9-14196) test data.

The transmitter side of all six modules built under this contract went together well and the test data was very close to the data obtained from the original breadboard module built under NAS9-14196. The transmitter test data for all seven modules used for this array subsystem is summarized in Table 3-1. As seen in this table, all the modules either met or were close to the contract design goals. The module transmitter input VSWR averaged 1.5:1, transmitter power output averaged +35 dBm, and transmitter gain averaged 22 dB. The module-to-module phase standard deviation averaged between 16 and 21 degrees. The design goal for this phase variation was less than one-half the smallest bit (which is 45 degrees).

The receiver side of all six modules built under this contract did not work as well as the original breadboard module built under NAS9-14196. The basic problem in the receiver area was the Avantek AT-4641 transistor shipment. The microwave parameters of the devices received on this contract were different from the microwave parameters of the devices received under NAS9-14196. The microwave parameters involved were the transistor S-parameter windows and the required source impedance for best noise performance. These differences caused the gain, gain flatness, and noise figure of the receiver side of the modules to be worse than the original breadboard module (MSN 001). The only way to improve performance on the present contract was to reorder all transistors, redesign the low-noise amplifier circuit, and reoptimize the receiver interfaces. Because this improvement would have required increased time and money and because timely execution of the contract was critical to supply antenna array data to NASA, module receiver performance was somewhat degraded in order to meet the schedule.

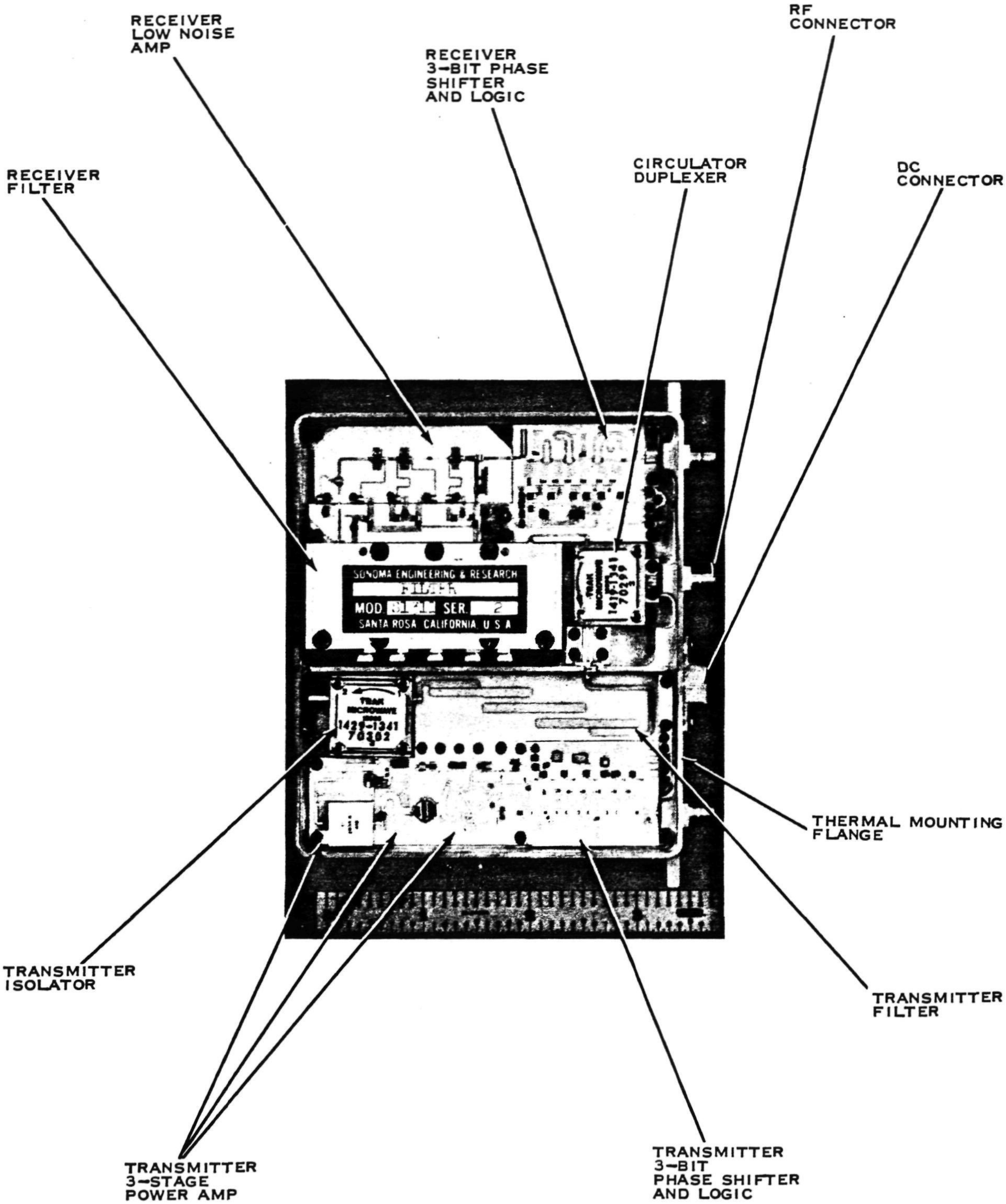


Figure 3-1. SPACS II Outer Module Layout Configuration

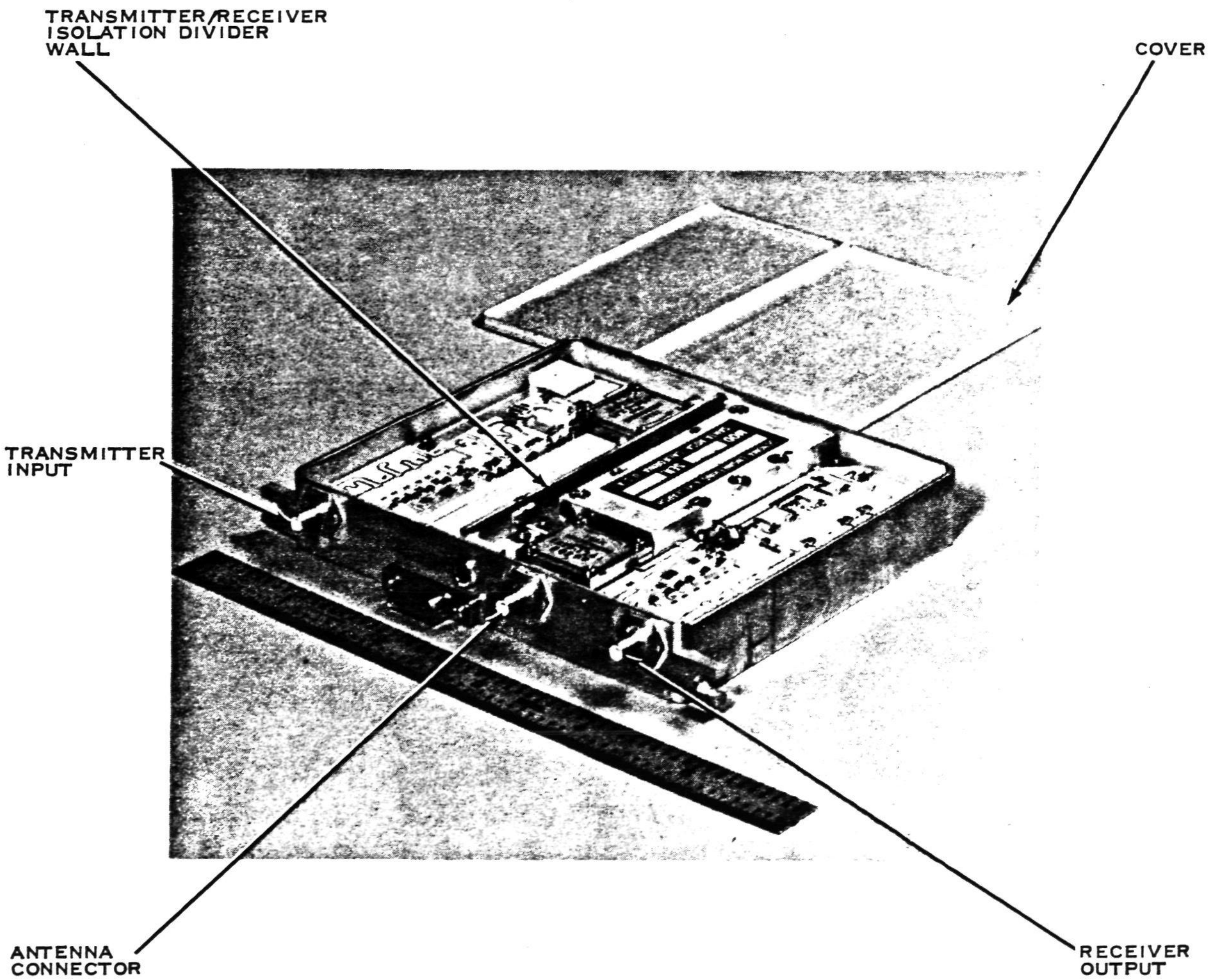


Figure 3-2. SPACS II Outer Module and Cover

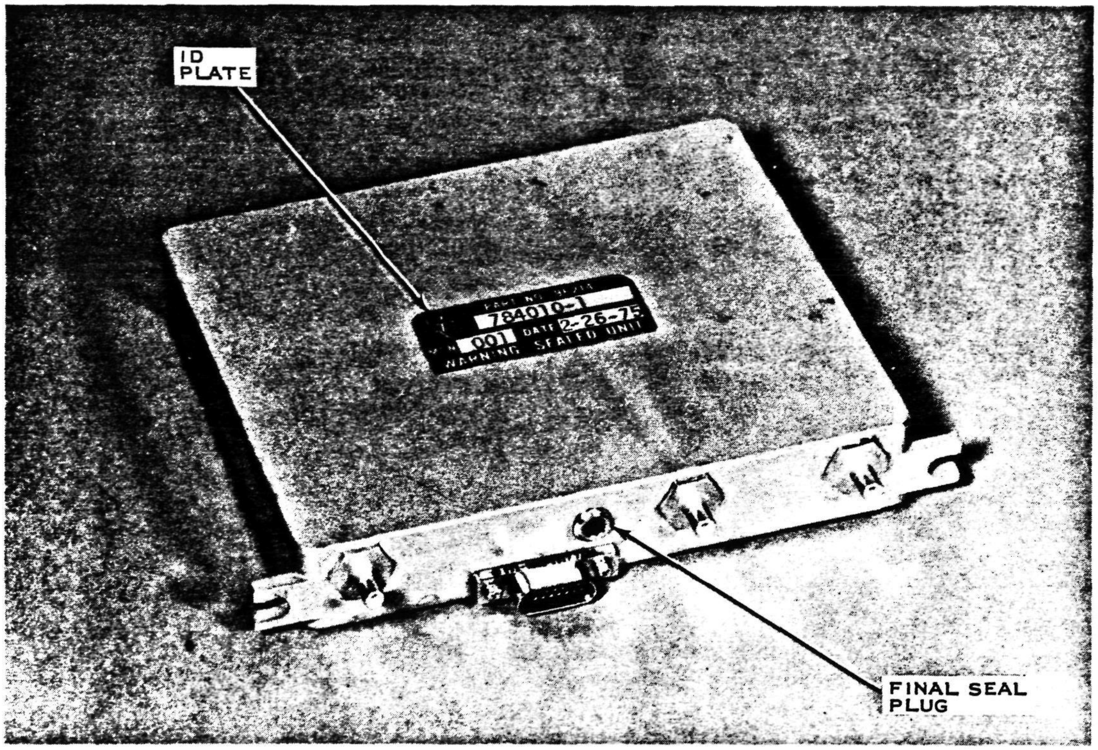


Figure 3-3. SPACS II Final Sealed Outer Module

Table 3-1. Summary of SPACS II Engineering Module Transmitter Test Data

(All data given for a module input power level of +13 dBm and at 0-degree reference phase length.)

	2217.5 MHz				2287.5 MHz			
Outer Module Serial Number P/N SK784010-1	Input VSWR	Output Power (dBm)	Gain (dB)	Phase Length (Degrees)	Input VSWR	Output Power (dBm)	Gain (dB)	Phase Length (Degrees)
MSN 001 (BB Unit)	1.43	34.8	21.4	84.0	1.87	35.7	22.7	78.2
MSN 003 (EM Unit)	1.34	35.6	22.6	72.6	2.19	35.0	22.0	125.9
MSN 004 (EM Unit)	1.17	35.3	22.3	62.5	2.12	34.2	21.2	93.5
MSN 005 (EM Unit)	1.46	35.2	22.2	65.3	1.35	34.0	21.1	108.8
MSN 006 (EM Unit)	1.82	35.0	22.0	82.2	1.55	35.7	22.7	65.5
MSN 007 (EM Unit)	1.50	35.7	22.7	51.5	1.07	35.6	22.6	82.6
Inner Module P/N SK446962-1	X	X	X	X	X	X	X	X
MSN 002 (EM Unit)	1.38	35.2	22.2	37.9	1.16	35.0	22.0	105.9
Mean Values, $\overline{X}$, All Modules	1.44	35.3	22.3	65.1	1.6	35.0	22.0	94.3
Standard Deviation, S, All Modules	0.2	0.3	0.3	16.5	0.5	0.7	0.7	20.7

To ensure that this problem does not reoccur in any future work, stricter specifications will be placed on the transistor S-parameter windows and source impedance for best noise figure. However, these stricter specifications will double the price of the AT-4641 transistors. Also, for any future module work, a variable thin-film attenuator will be placed in the output of the low-noise amplifier to allow adjustment of the module receiver gain. This should ensure that the receiver side of the module will have 30 dB of gain with ±1-dB maximum variation from module to module.

The receiver test data for the seven modules used for this array subsystem is summarized in Table 3-2, which shows that all the modules either met or were close to the contract design goals. The module receiver input VSWR averaged 2.1:1, receiver noise figure averaged between 5.3 and 6.0 dB, and receiver gain averaged 31.6 dB. Phase variations were between 20 to 30 degrees. The noise figure exceeded the design goal of 5.0 dB because of the transistor problem previously mentioned. The module-to-module phase variation also exceeded the goal of 22.5 degrees, and the module-to-module gain variation was greater than the design goal of ±1 dB. Again, this was due to the transistor problem previously discussed.

As shown by the data sheets in Appendix B, the module receivers have low intermodulation products and 1-dB compression points between +1 and +10 dBm, and work under fully duplexed operation with the transmitter and receiver used at the same time. With the exception of the low-noise transistor problem, the outer modules performed as expected and met the majority of design goals.

B. INNER MODULE (P/N SK 446962-1) DESIGN AND EVALUATION

One center module was built using existing circuits from the previously discussed outer modules. The center module did not have a requirement for phase shifters in either the transmitter or receiver sections. In place of the 3-bit phase shifters, simple phase adjust networks were used in the transmitter and receiver. The center module had the additional capability of receiving L-band signals at 1775.5 MHz and 1831.8 MHz, and outputting these signals through a separate RF connector.

Figures 3-4 and 3-5 are photographs of the completed center module. This center module is similar to the outer modules but is 1 inch longer because of the extra circuitry required.

The transmit phase adjust network shown in the figures consists of four spurline phase adjustment (analog) sections, with each capable of being adjusted from 10 to 100 degrees in 5-degree increments. This adjustment takes place by moving welded gold ribbons up or down the spurlines as required. The transmit phase adjustment network is designed to provide ±180 electrical degrees of adjustment to ensure its phase length is close to that of the other six outer modules. A 2-dB thin-film pad is mounted on the phase adjust network. Since this circuit has no diodes to create as much loss as the

Table 3-2. Summary of SPACS II Engineering Module Receiver Test Data

(All data given for a module input power level of -40 dBm and at 0-degree reference phase length.)

	2041.9 MHz				2106.4 MHz			
Outer Module Serial Number P/N SK784010-1	Input VSWR	Noise Figure (dB)	Gain (dB)	Phase Length (Degrees)	Input VSWR	Noise Figure (dB)	Gain (dB)	Phase Length (Degrees)
MSN 001 (BB Unit)	2.03	4.6	34.5	-118.9	2.32	4.1	34.5	-57.4
MSN 003 (EM Unit)	1.26	6.1	33.1	-149.1	1.34	5.3	32.1	-113.3
MSN 004 (EM Unit)	2.85	6.2	30.7	-108.9	2.04	5.1	30.0	-62.1
MSN 005 (EM Unit)	1.30	6.1	32.0	-162.1	1.78	5.8	31.5	-134.0
MSN 006 (EM Unit)	1.32	5.7	33.1	-133.6	1.29	4.9	33.9	-88.7
MSN 007 (EM Unit)	1.58	6.9	30.5	-154.7	1.70	5.6	30.4	-109.6
Inner Module P/N SK446962-1	X	X	X	X	X	X	X	X
MSN 002 (EM Unit)	3.2	6.3	27.3	-151.5	8.6	6.0	29.2	-121.4
Mean Values, $\overline{X}$, All Modules	1.93	6.0	31.6	-139.8	2.72	5.3	31.7	-98.1
Standard Deviation, S, All Modules	0.8	0.7	2.37	19.9	2.62	0.6	2.0	29.5

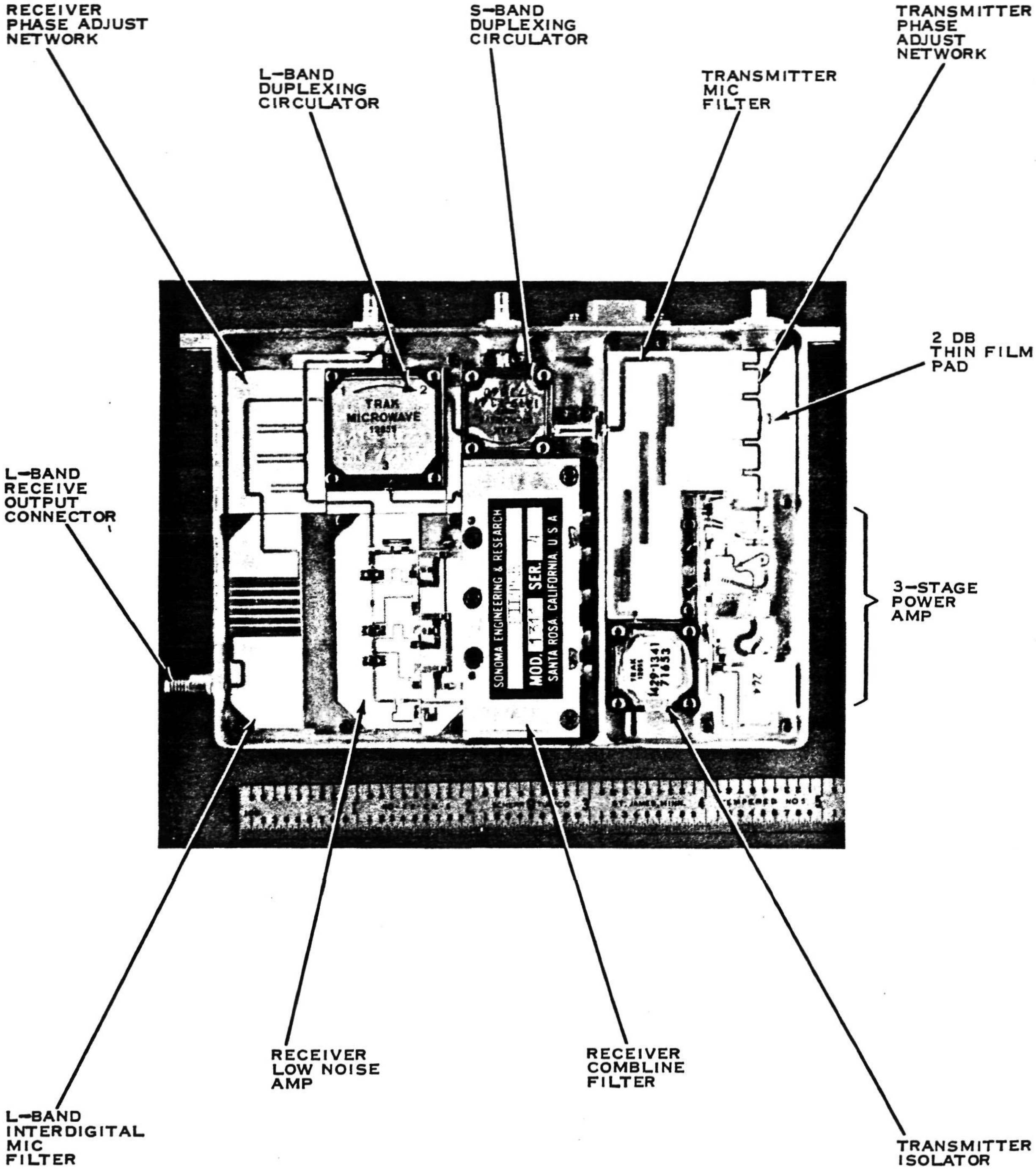


Figure 3-4. SPACS II Center Module Layout Configuration, Top View

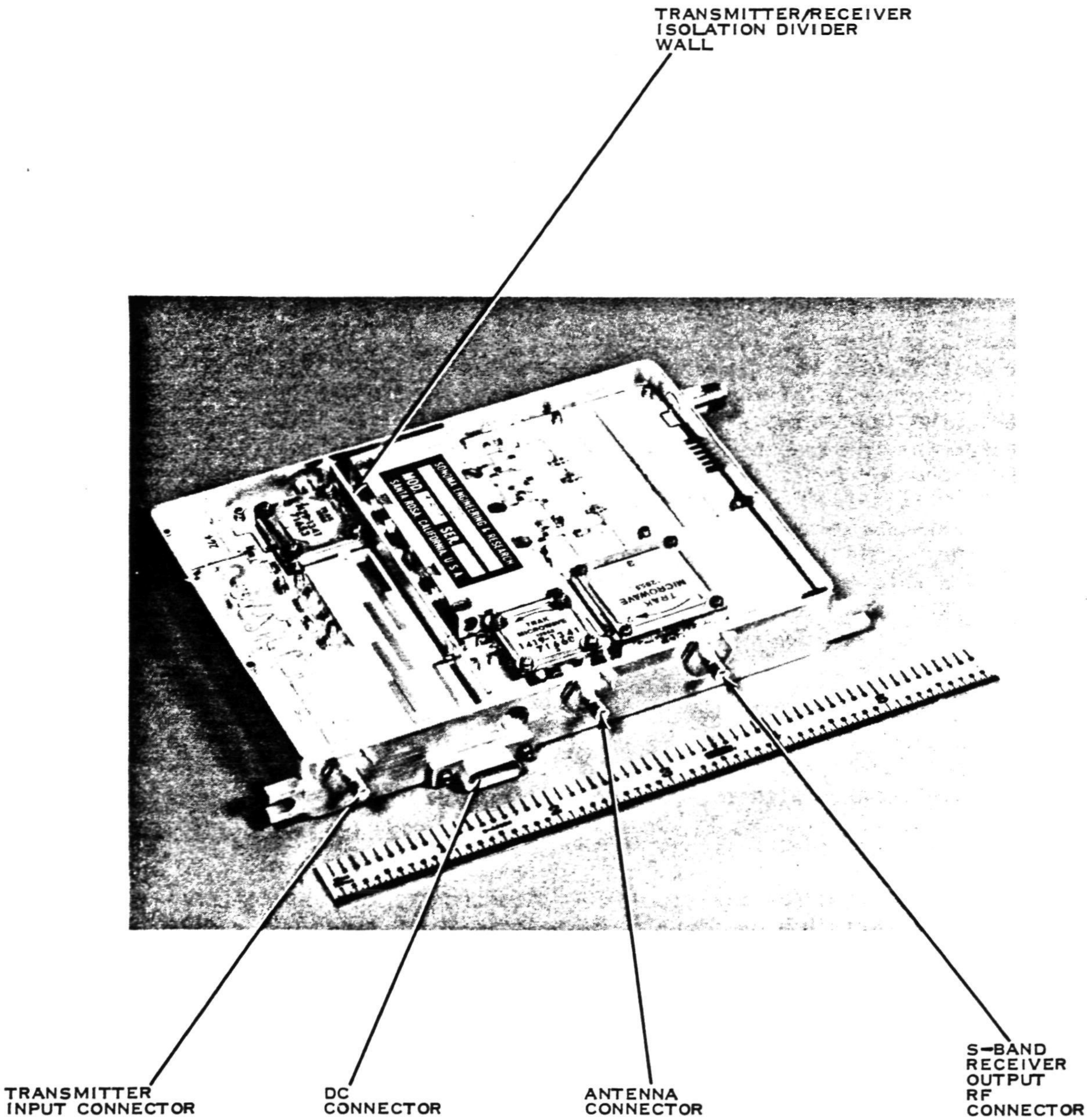


Figure 3-5. SPACS II Center Module, Oblique View

original phase shifter circuit, this attenuator is required to ensure that the input drive power to the three-stage power amplifier remains the same as the other six modules. Most of the module circuits, including the phase adjust circuit, are built using MIC construction on Al_2O_3 ceramic substrates. ANA data taken on a transmit phase adjust network is shown in Table 3-3.

The receiver phase adjust network (Figures 3-4 and 3-5) consists of three spurline phase adjustment (analog) sections, with one capable of being adjusted from 10 to 110 degrees in 5-degree increments, and the other two sections capable of being adjusted from 10 to 140 degrees in 5-degree increments. This adjustment takes place by moving welded gold ribbons up or down the spurlines as required. The receiver phase adjust network is designed to provide ±180 electrical degrees of adjustment to ensure its phase length is close to that of the other six outer modules. A 50-ohm transmission line is also included on the receiver phase adjust circuit. This line routes the L-band receive signal from the L-band circulator to the L-band filter. The receive phase adjust network also uses microstrip construction techniques.

The thin-film pad used on the transmit phase adjust network is not included as part of the receiver phase adjust network. This is because there is approximately 1 dB of extra loss already in the receiver section due to the extra L-band circulator and 50-ohm routing lines. This already puts the gain of the center module receiver section close to that of the outer modules. ANA data was taken on the receive phase adjust network. Its loss was approximately 0.8 dB with a 1.2:1 VSWR.

The L-band circulator shown in Figure 3-4 properly routes the S-band and L-band receive signals. On receive, a signal enters the S-band duplexing circulator and is routed to the L-band circulator. The L-band circulator then routes the receive signal to the receiver combline filter.

If the receive signal is an S-band signal (2041.9 MHz or 2106.4 MHz), it passes through the receiver combline filter, is amplified, and passes out through the S-band receiver output RF connector. If the receive signal is an L-band signal (1775.5 MHz or 1831.8 MHz), it is reflected from the combline filter back to the L-band circulator. From the L-band circulator, the L-band receive signal is routed over the receive phase adjust network to the L-band MIC filter and through the L-band filter to the L-band output RF connector. The ANA test data taken on the L-band circulator is shown in Tables 3-4 and 3-5.

The L-band MIC filter shown in Figure 3-4 is an interdigitated type adapted from the AESPA contract NAS8-25847 with MSFC. This filter is a six-section (n = 6 resonators) Chebyshev bandpass design using microstrip construction on 0.025-inch-thick alumina ceramic. The length of the resonators is approximately a quarter wavelength at a center frequency of 1800 MHz. In an interdigitated design, each resonator is grounded at one end and open at the other end. This pattern is staggered across the filter as shown by Figure 3-6. This filter must have approximately 2-dB insertion loss at L-band receive frequencies and must reject S-band receive and transmit signals by at least 30 dB.

Table 3-3. Transmit Phase Adjust Circuit,

Automatic Network Analyzer Test Data

Conn device - Transmit phase adjust S/N 1; P/N SK446987; 5/12/75; DRD

FREQUENCY	REFL	ANGLE	RTN LS	VSWR	GAIN	PHASE	DELAY
2100.000	0.149	-105.9	16.5	1.351	-2.28	-160.6	0.702
2120.000	0.148	-107.4	16.6	1.348	-2.35	-165.7	0.728
2140.000	0.148	-108.3	16.6	1.346	-2.41	-170.9	0.686
2160.000	0.144	-108.5	16.8	1.338	-2.45	-175.9	0.685
2180.000	0.143	-109.0	16.9	1.334	-2.50	179.2	0.791
2200.000	0.151	-109.5	16.4	1.357	-2.60	173.5	0.728
2220.000	0.151	-110.9	16.4	1.354	-2.66	168.3	0.626
2240.000	0.139	-108.8	17.2	1.322	-2.61	163.7	0.656
2260.000	0.131	-111.2	17.7	1.301	-2.67	159.0	0.701
2280.000	0.128	-113.2	17.9	1.293	-2.70	154.0	0.725
2300.000	0.126	-115.6	18.0	1.287	-2.75	148.8	0.726
2320.000	0.124	-118.4	18.2	1.282	-2.75	143.5	0.718
2340.000	0.124	-121.8	18.2	1.282	-2.79	138.4	0.752
2360.000	0.126	-125.8	18.0	1.288	-2.83	132.9	0.722
2380.000	0 128	-130.1	17.9	1.293	-2.90	127.7	0.734
2399.999	0.131	-134.5	17.7	1.300	-2.92	122.5	0.734

Table 3-4. L-Band Circulator (P/N 1419-1123), Automatic Network Analyzer Test Data for Through Path

Conn device - TRAK L-band circulator; P/N 1419-1123; S/N 72105, port 2 to port 3 6/6/75; DRD

FREQUENCY	REFL	ANGLE	RTN LS	VSWR	GAIN	PHASE	DELAY
1500.000	0.443	123.2	7.1	2.589	-2.06	-94.5	1.048
1525.000	0.396	116.9	8.0	2.311	-1.65	-104.0	1.198
1550.000	0.351	110.3	9.1	2.083	-1.64	-114.8	1.401
1575.000	0.309	102.4	10.2	1.894	-1.55	-127.4	1.272
1600.000	0.284	94.1	10.9	1.793	-1.19	-138.8	1.078
1625.000	0.267	87.9	11.5	1.729	-0.99	-148.5	1.212
1650.000	0.241	82.5	12.4	1.634	-1.05	-159.4	1.378
1675.000	0.210	73.8	13.6	1.531	-0.97	-171.8	1.206
1700.000	0.196	64.2	14.2	1.488	-0.80	177.3	1.241
1725.000	0.180	56.2	14.9	1.438	-0.78	166.1	1.257
1750.000	0.158	48.1	16.0	1.376	-0.62	154.8	1.052
1775.000	0.133	36.5	17.5	1.306	-0.46	145.4	1.043
1800.000	0.114	21.3	18.8	1.258	-0.59	136.0	1.278
1825.000	0.099	6.1	20.1	1.220	-0.81	124.5	1.336
1850.000	0.084	-10.5	21.5	1.183	-0.68	112.4	1.080
1875.000	0.071	-30.0	22.9	1.153	-0.40	102.7	0.975
1900.000	0.062	-50.8	24.1	1.133	-0.51	94.0	1.268
1925.000	0.057	-75.0	24.9	1.121	-0.75	82.5	1.298
1950.000	0.058	-101.1	24.7	1.124	-0.69	70.9	1.069
1975.000	0.066	-120.6	23.6	1.142	-0.50	61.2	0.944
2000.000	0.072	-136.6	22.8	1.156	-0.55	52.7	1.110
2025.000	0.079	-151.9	22.0	1.172	-0.80	42.7	1.285
2050.000	0.088	-164.4	21.1	1.194	-0.85	31.2	1.087
2075.000	0.098	-174.6	20.2	1.217	-0.71	21.4	0.996
2100.000	0.105	176.2	19.6	1.234	-0.75	12.4	1.118
2125.000	0.112	166.6	19.0	1.251	-0.87	2.4	1.079
2150.000	0.120	156.0	18.4	1.272	-0.89	-7.3	1.040
2175.000	0.126	145.8	18.0	1.289	-0.99	-16.7	1.103
2199.999	0.130	134.5	17.7	1.300	-1.17	-26.6	1.103

Table 3-5. L-Band Circulator (P/N 1419-1123),
Automatic Network Analyzer Test Data for Isolated Path
Port 3 to Port 2

FREQUENCY	REFL	ANGLE	RTN LS	VSWR	GAIN	PHASE	DELAY
1500.000	0.388	-166.7	8.2	2.267	-10.40	166.6	1.575
1525.000	0.334	-173.3	9.5	2.002	-10.55	152.5	1.408
1550.000	0.286	-178.9	10.9	1.800	-10.96	139.8	1.514
1575.000	0.244	176.4	12.3	1.644	-11.79	126.2	1.796
1600.000	0.208	172.6	13.6	1.526	-12.48	110.0	1.564
1625.000	0.175	169.5	15.1	1.424	-12.93	95.9	1.343
1650.000	0.150	166.6	16.5	1.352	-13.87	83.8	1.537
1675.000	0.125	164.8	18.0	1.287	-15.10	70.0	1.572
1700.000	0.104	163.0	19.6	1.233	-16.10	55.9	1.401
1725.000	0.083	161.8	21.6	1.182	-17.16	43.3	1.135
1750.000	0.065	162.6	23.8	1.138	-18.48	33.0	1.243
1775.000	0.046	169.6	26.8	1.096	-20.14	21.9	1.221
1800.000	0.032	-170.9	30.0	1.066	-21.92	10.9	0.982
1825.000	0.030	-137.4	30.5	1.062	-23.91	2.0	0.630
1850.000	0.041	-113.7	27.7	1.086	-26.01	-3.7	0.239
1875.000	0.058	-105.7	24.7	1.124	-28.42	-5.8	0.519
1900.000	0.077	-104.2	22.3	1.167	-30.49	-1.1	1.191
1925.000	0.091	-107.9	20.9	1.199	-31.64	9.6	0.860
1950.000	0.109	-113.9	19.3	1.243	-31.54	17.3	0.326
1975.000	0.128	-119.6	17.8	1.295	-30.45	20.3	0.149
2000.000	0.143	-123.4	16.9	1.333	-29.77	18.9	0.681
2025.000	0.152	-129.5	16.4	1.359	-28.88	12.8	1.025
2050.000	0.163	-136.9	15.7	1.391	-28.51	3.6	1.232
2075.000	0.176	-144.0	15.1	1.428	-28.46	-7.5	1.009
2100.000	0.189	-150.2	14.5	1.466	-28.82	-16.6	1.140
2125.000	0.196	-156.4	14.2	1.486	-29.61	-26.8	0.717
2150.000	0.202	-164.8	13.9	1.507	-31.41	-33.3	0.147
2175.000	0.212	-174.0	13.5	1.537	-34.18	-32.0	2.566
2199.999	0.216	176.7	13.3	1.552	-36.20	-8.9	2.566

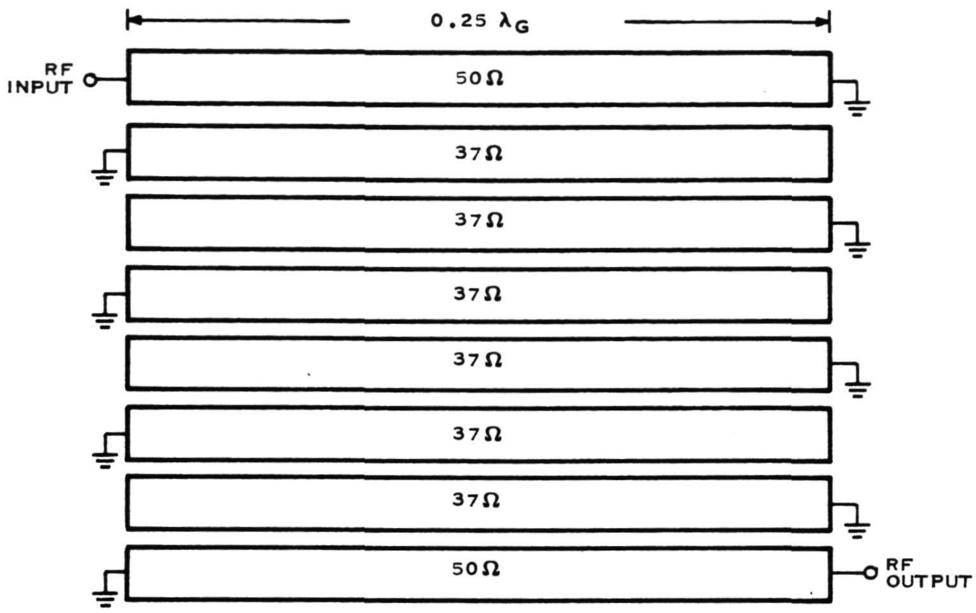


Figure 3-6. L-Band MIC Interdigitated Filter Topology

ANA test data on this L-band filter is shown in Table 3-6. This data shows that the filter had less than 2-dB loss at 1775.5 and 1831.8 MHz. Also, it averaged over 40 dB of rejection across the S-band transmit and receive frequencies.

The specifications and test procedures for the inner T/R module are also given by Texas Instruments drawing number SKDD 301 (Appendix A). The individual module test data for the center module (MSN 002) built under this contract is given as drawing number SKDD 302 (Appendix C). A summary of the S-band transmitter and receiver data was included in Tables 3-1 and 3-2 for comparison with the other modules built under this contract. The module L-band receive loss was 3.75 dB at 1775.5 MHz and 3.39 dB at 1831.8 MHz, which meets the module design goal of less than 4 dB.

As with outer modules, the transmitter side of the center module went together well and met all of the design parameters. The receiver side of the center module had the same problems with respect to gain uniformity, gain flatness, and noise figure as previously discussed for the outer modules.

Table 3-6. L-Band MIC Interdigitated Filter,
Automatic Network Analyzer Test Data

Conn device; L-band filter; P/N SK446972-1; S/N 5; 5/13/75; DRD

FREQUENCY	REFL	ANGLE	RTN LS	VSWR	GAIN	PHASE	DELAY
1500.000	0.934	129.2	0.6	29.109	-16.11	-129.5	2.405
1525.000	0.874	110.7	1.2	14.835	-11.03	-151.1	4.355
1550.000	0.615	79.8	4.2	4.198	-4.99	169.7	7.323
1575.000	0.228	141.1	12.8	1.592	-2.16	103.8	5.273
1600.000	0.573	126.5	4.8	3.687	-3.51	56.3	3.565
1625.000	0.614	100.1	4.2	4.182	-3.89	24.2	3.542
1650.000	0.502	73.2	6.0	3.020	-2.92	-7.7	4.230
1675.000	0.245	48.3	12.2	1.650	-1.79	-45.7	4.699
1700.000	0.127	129.0	17.9	1.292	-1.59	-88.0	4.329
1725.000	0.312	120.8	10.1	1.905	-1.94	-127.0	4.014
1750.000	0.347	96.1	9.2	2.061	-2.07	-163.1	4.189
1775.000	0.250	75.9	12.1	1.666	-1.89	159.2	4.616+
1800.000	0.136	96.5	17.3	1.314	-1.66	117.7	4.616
1825.000	0.214	117.0	13.4	1.543	-1.82	76.1	4.538+
1850.000	0.245	94.5	12.2	1.648	-2.04	35.3	4.830
1875.000	0.131	68.4	17.6	1.303	-1.89	-8.2	5.223
1900.000	0.098	168.8	20.2	1.216	-2.04	-55.2	5.639
1925.000	0.221	141.6	13.1	1.566	-2.52	-106.0	6.531
1950.000	0.112	137.2	19.0	1.253	-2.75	-164.7	8.382
1975.000	0.325	174.4	9.8	1.962	-4.23	119.8	12.723
2000.000	0.494	-175.5	6.1	2.950	-9.73	5.3	6.621
2025.000	0.825	141.2	1.7	10.445	-31.57	-54.3	10.032+
2050.000	0.872	117.7	1.2	14.636	-42.87	36.0	0.241
2075.000	0.893	101.6	1.0	17.737	-42.04	38.2	0.906
2100.000	0.911	88.3	0.8	21.360	-43.54	30.0	1.311
2125.000	0.918	76.7	0.7	23.424	-45.55	18.2	0.920
2150.000	0.922	66.1	0.7	24.525	-47.68	10.0	1.208
2175.000	0.923	56.3	0.7	25.085	-49.85	-0.9	0.604
2200.000	0.920	46.9	0.7	23.884	-52.11	-6.3	0.723
2225.000	0.921	37.9	0.7	24.398	-53.70	-12.9	0.200
2250.000	0.921	29.0	0.7	24.397	-55.32	-14.7	0.036
2275.000	0.922	20.4	0.7	24.712	-56.37	-15.0	0.350
2300.000	0.927	11.8	0.7	26.377	-57.45	-18.1	0.419
2325.000	0.935	3.2	0.6	29.782	-58.18	-21.9	0.036
2350.000	0.939	-5.3	0.6	31.581	-59.97	-22.2	0.122
2375.000	0.943	-13.6	0.5	34.269	-60.45	-21.1	0.394
2400.000	0.951	-21.8	0.4	39.486	-59.69	-24.7	0.696
2425.000	0.948	-30.1	0.5	37.798	-59.97	-18.4	0.327
2450.000	0.946	-38.1	0.5	35.989	-58.97	-21.4	0.020
2475.000	0.950	-46.1	0.4	38.736	-59.78	-21.2	1.131
2499.999	0.949	-54.2	0.5	38.354	-59.73	-11.0	1.131

C. SUMMARY AND RECOMMENDATIONS

In summary, the modules went together well and met the majority of design parameters. There was no problem with the transmitter side of the modules, which had performance data very close to the original breadboard module (MSN 001).

The receiver section had a few problems originating in the AT-4641 transistor shipment. Overall, the receiver met the majority of design parameters and worked well enough to give good antenna array performance. The following list describes the areas in the receiver side that need improvement for the next module design.

1. Add a variable thin-film attenuator pad between the low-noise amplifier and the receiver phase shifter so that module receiver gain can be set at 30 ±1 dB. This will ensure a more uniform module-to-module gain.

2. Place tighter specification windows on the low-noise amplifier AT-4641 transistors. This will ensure that the gain flatness and noise figures will be met for a given low-noise amplifier circuit design. The parameters to be more restrictive are the S parameters (especially S_{11} and S_{22}) and source impedance for optimum low-noise figure.

3. Add grounding posts at quarter-wave intervals in the module (especially on the receiver side) to prevent any spurious oscillations due to cavity-type moding.

4. Add a grounding clip between the combline filter and the module cover for better grounding on this unit, which will result in better transmitter rejection.

5. Improve the phase alignment test procedure for better module-to-module phase length uniformity. Overall, transmit and receive phase length variations should be reduced to less than ±10 degrees.

With these improvements incorporated into future SPACS modules, better array performance can be assured. These improvements should reduce overall module production costs and simplify module testing.

SECTION IV

DC AND LOGIC MANIFOLD DEVELOPMENT

The second major item developed on this contract is a dc and logic mutlilayer board (MLB) manifold. All dc and logic signals enter the array through a 31-pin MS connector located on the array outer housing. The connector pin assignment is detailed in Texas Instruments drawing number SK446943. From this connector, all dc and logic signals are routed to the dc and logic manifold through a short wiring harness. The details of this wiring harness are covered by Texas Instruments drawing number SK446985. This wiring harness has two branches. All dc signals enter a 15-pin miniature connector located on the dc and logic manifold (pin assignments for this connector are detailed in Texas Instruments drawing number SK446979). All logic signals enter a 31-pin miniature connector located on the dc and logic manifold (pin assignments for this connector are detailed in Texas Instruments drawing number SK446980).

In future contracts, a small steering controller will be developed capable of taking five serial logic commands as inputs and converting them to the proper logic commands to input to each of the six T/R microelectronics modules. This steering controller module will eventually plug into the 31-pin logic connector on the dc and logic manifold.

The dc and logic manifold takes the major dc and logic input signals from the array input connector and properly routes them to each of the seven modules. In addition to the two connectors already described, the dc and logic manifold has seven additional 15-pin miniature connectors. The pin assignment for six of these connectors is detailed by Texas Instruments drawing number SK446982, and the seventh connector is covered by Texas Instruments drawing number SK446981.

Figures 4-1 and 4-2 show the dc and logic manifold designed, fabricated, and tested on this contract. As shown by these figures, three clearance holes for each module are drilled in the dc and logic manifold to provide access to the RF connectors that go to the transmit manifold, receive manifold, and antenna elements.

The dc and logic manifold, constructed of 12 conductor layers, is 10.4 inches in diameter and 0.095 inch thick. It contains six plastic insulating sheets with copper on both sides of the sheet. After etching each conductor layer with the proper artwork, the sheets are bonded together with glass cloth and epoxy adhesive. Holes that feed through to connect each of the proper layers are plated through using special techniques. Detailed dimensions and construction techniques are covered in Texas Instruments drawing number SK446976.

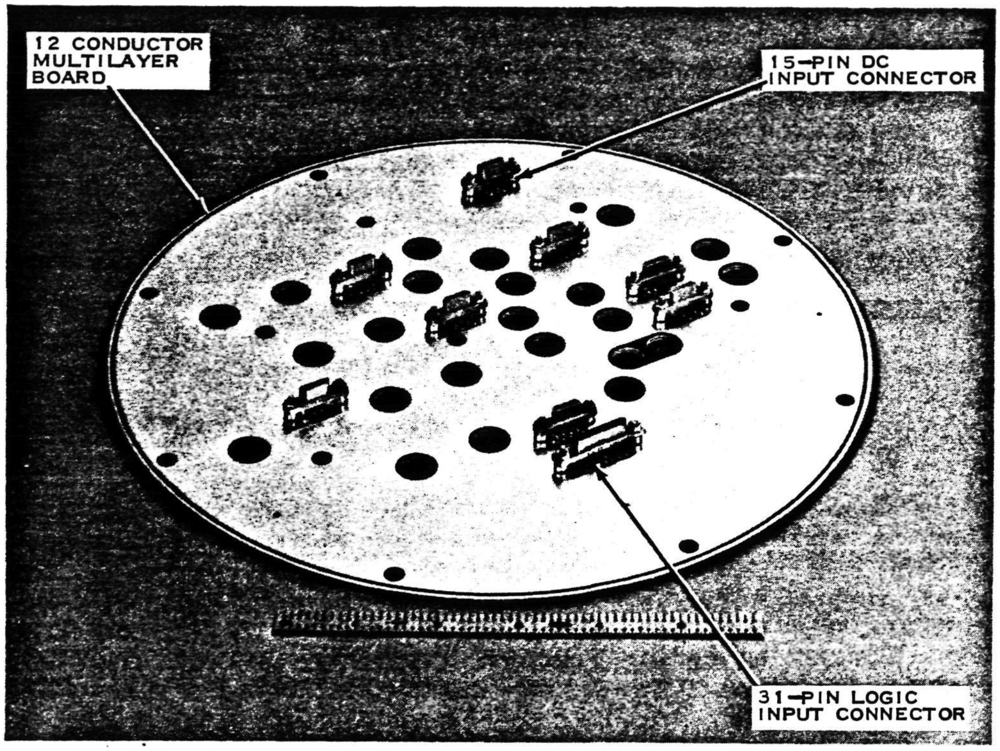


Figure 4-1. SPACS II DC and Logic Manifold
Assembled, Oblique View

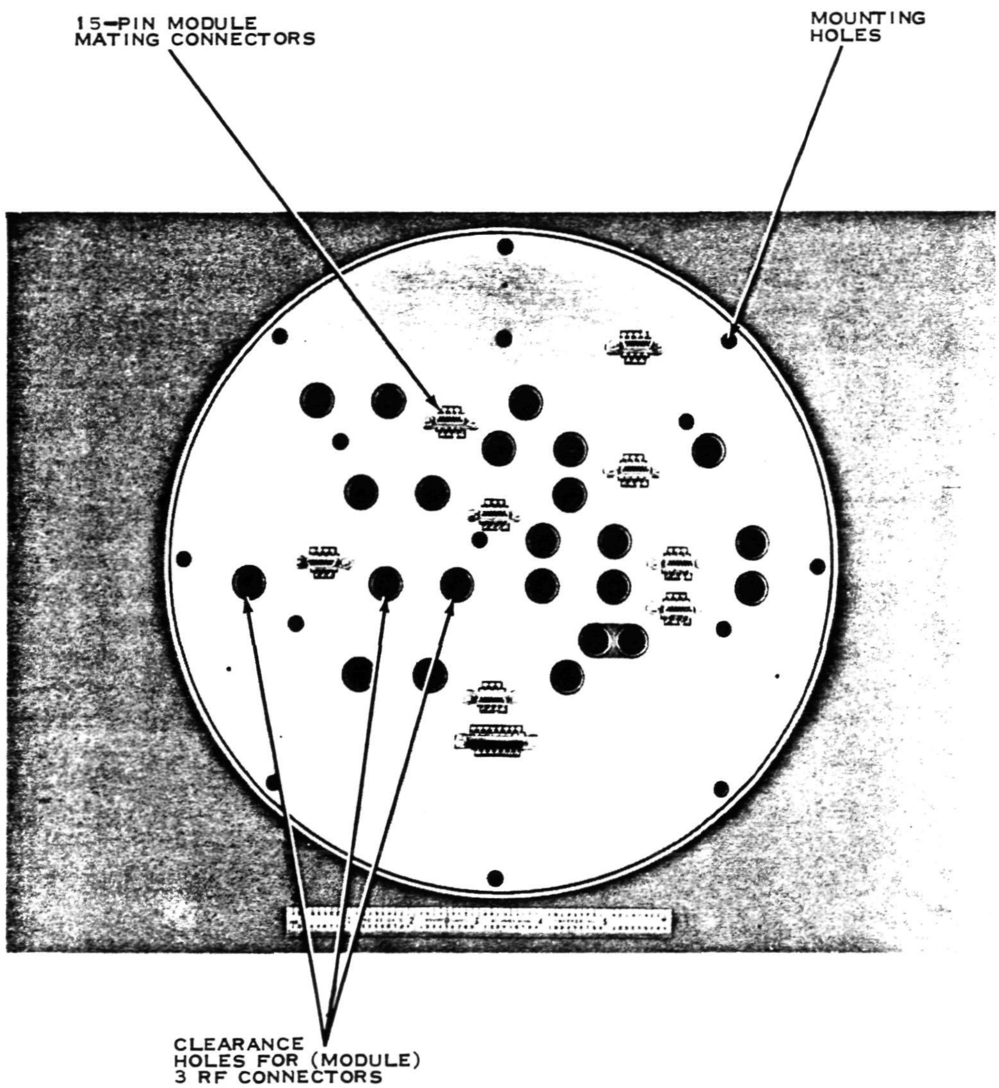


Figure 4-2. SPACS II DC and Logic Manifold, Top View

After routing and drilling the clearance holes, a special plating material is deposited on the outer ground planes. Following fabrication, the board is checked with an ohmmeter to ensure good electrical continuity. The interconnection diagram is covered in Texas Instruments drawing number SK446988.

After checkout, the manifold miniature connectors are installed and soldered into place. Following assembly, final electrical tests and mechanical inspections are performed in accordance with Texas Instruments drawing number SKDD 501 (Appendix D). These tests and inspections ensure overall compatibility with the array requirements.

The 12 individual conductor layers that make up the dc and logic manifold are listed in Table 4-1.

Table 4-1. DC and Logic Manifold Conductor Layer Assignment

Table of Layers			
No.	Description	Remarks	Copper Weight (ounces)
L1	Top layer and ground	Pads and plane	1
L2	Power, +22 Vdc	Plane	1
L3	Signal, transmitter clock	Conductor lines	1
L4	Power, +12 Vdc	Conductor lines	1
L5	Signal, receiver clock	Conductor lines	1
L6	Power, +5 Vdc	Plane	1
L7	Signal, 45° bit	Conductor lines	1
L8	Ground	Plane	1
L9	Signal, 90° bit	Conductor lines	1
L10	Signal, Enable	Plane	1
L11	Signal, 180° bit	Conductor lines	1
L12	Bottom layer and ground	Pads and plane	1

Some layers are purely conductor planes (solid conductors) and other layers have signal lines etched on them.

In summary, the dc and logic manifold was designed, built, and tested. It performed well electrically and was mechanically compatible with the rest of the array hardware, including the T/R microelectronics modules. All dc paths have sufficient safety margins to carry the required current levels. All logic signal paths provide sufficient isolation to prevent signal crosstalk between layers. The dc and logic manifold works perfectly.

SECTION V

ARRAY INTEGRATION AND SUBSYSTEM TESTS

A. ARRAY INTEGRATION

The third major task required by the contract was the integration and testing of all antenna subsystem hardware developed for Contract NAS9-14196 with the hardware developed for this contract. The hardware involved with this effort is listed below:

- Antenna elements and balun board
- Transmit RF manifold
- Receive RF manifold
- DC and logic manifold
- One BB T/R outer module
- Five EM T/R outer modules
- One EM T/R center module
- Array housing
- Short array wiring harness
- Three RF semirigid cables
- Finned heatsink and fan.

No problems were encountered during hardware integration; all hardware was compatible from both mechanical and electrical standpoints. The only minor difficulty encountered during testing was the array overheating. The array was tested on an outdoor antenna range with temperatures reaching 105°F. In addition, RF-absorbing insulation was placed around the back of the array to prevent reflections when using the standard gain horn reference unit. This material prevented any air flow around the array. The array will eventually have a liquid-cooled heatsink incorporated as an integral part of the unit. To prevent the breadboard array from overheating during testing, a finned heatsink and fan (+26 Vdc at 180 mA) was added to the back of the array. This reduced the array temperature from 60°C to 30°C.

Figures 5-1 through 5-5 show the integrated antenna subsystem configuration that was tested. Overall array dimensions, including the finned heatsink, are 10 inches in diameter (array body) by 7 inches deep. Final weight of the shipped array was 17 pounds.

B. ANTENNA ARRAY SUBSYSTEM TESTS

The SPACS II antenna array subsystem was tested on an outdoor antenna range at Texas Instruments, Dallas. The array was mounted in a large curved

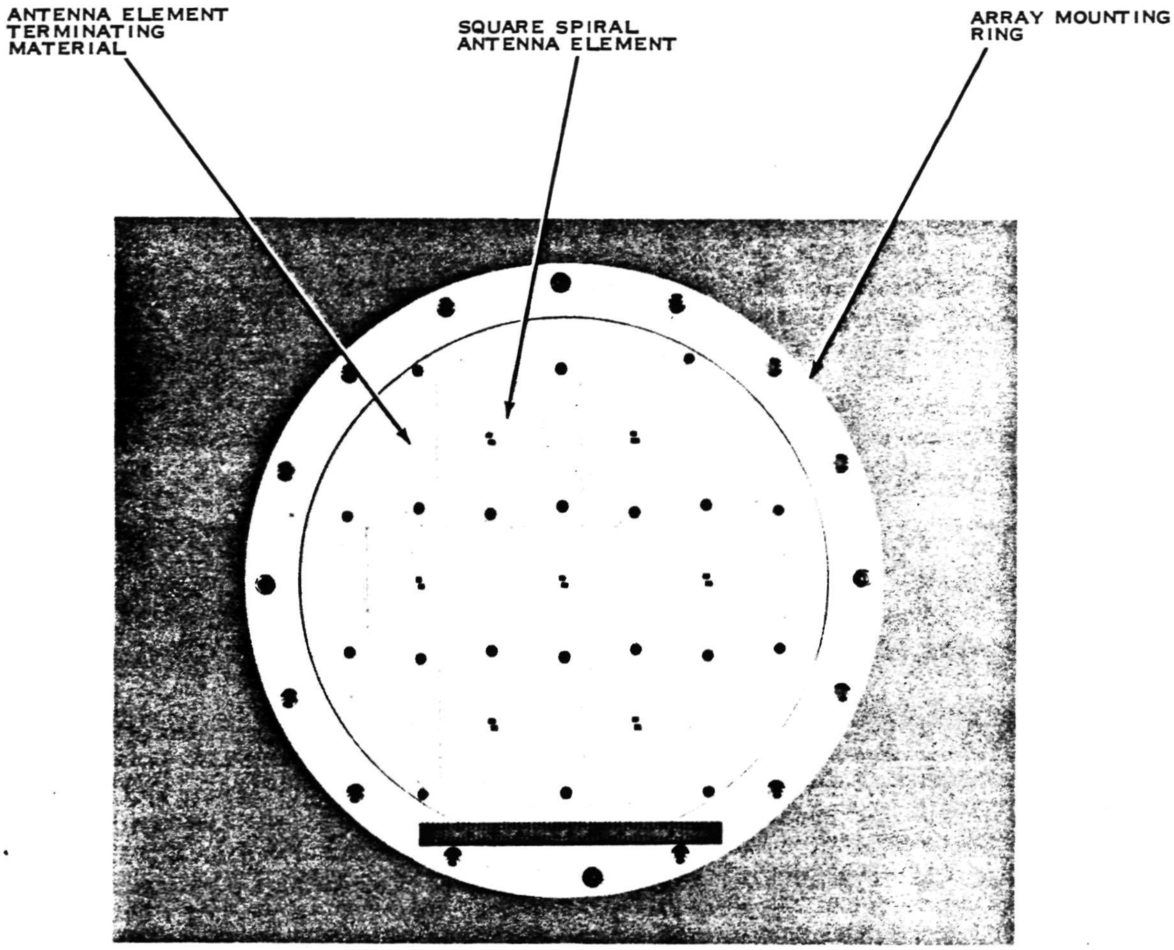


Figure 5-1. SPACS II Antenna Subsystem,
Antenna Element View

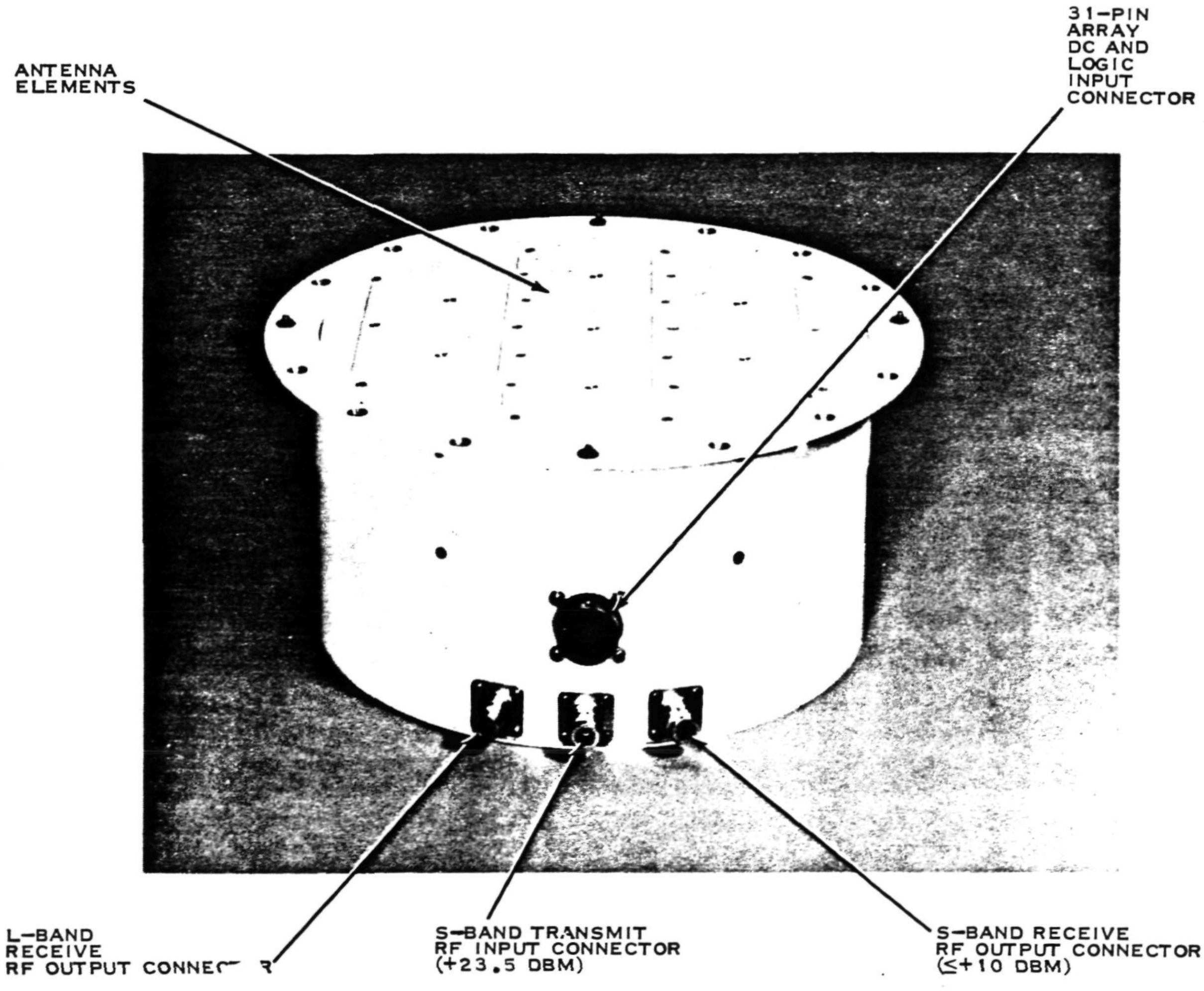


Figure 5-2. SPACS II Antenna Subsystem,
Side View with Connectors

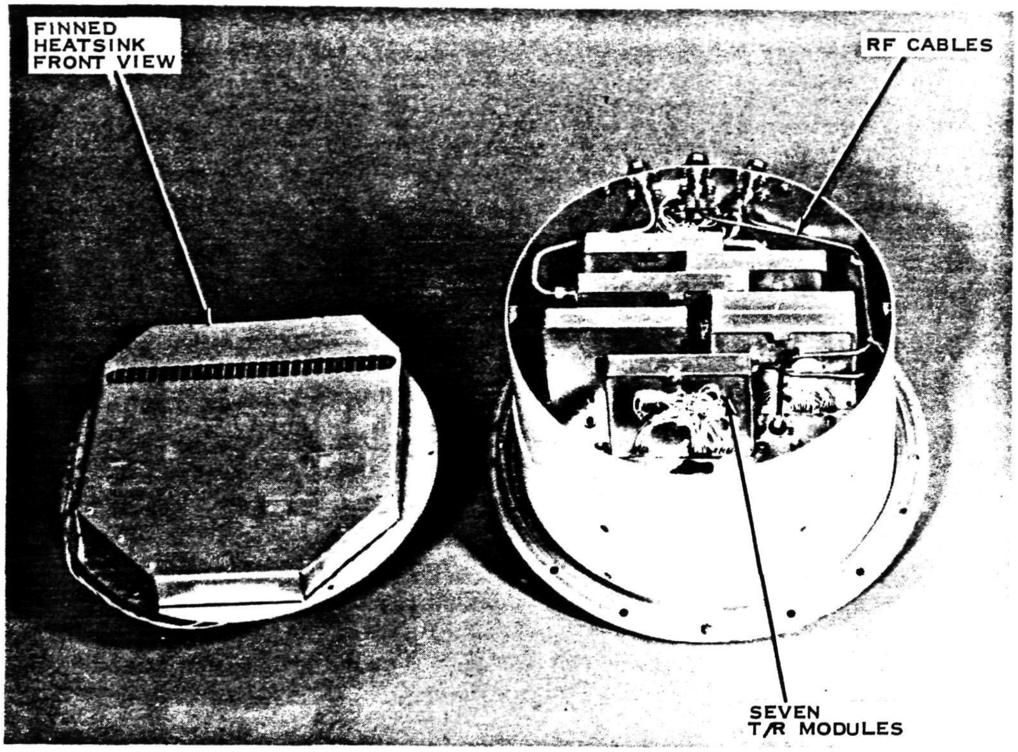


Figure 5-3. SPACS II Antenna Subsystem, Internal View

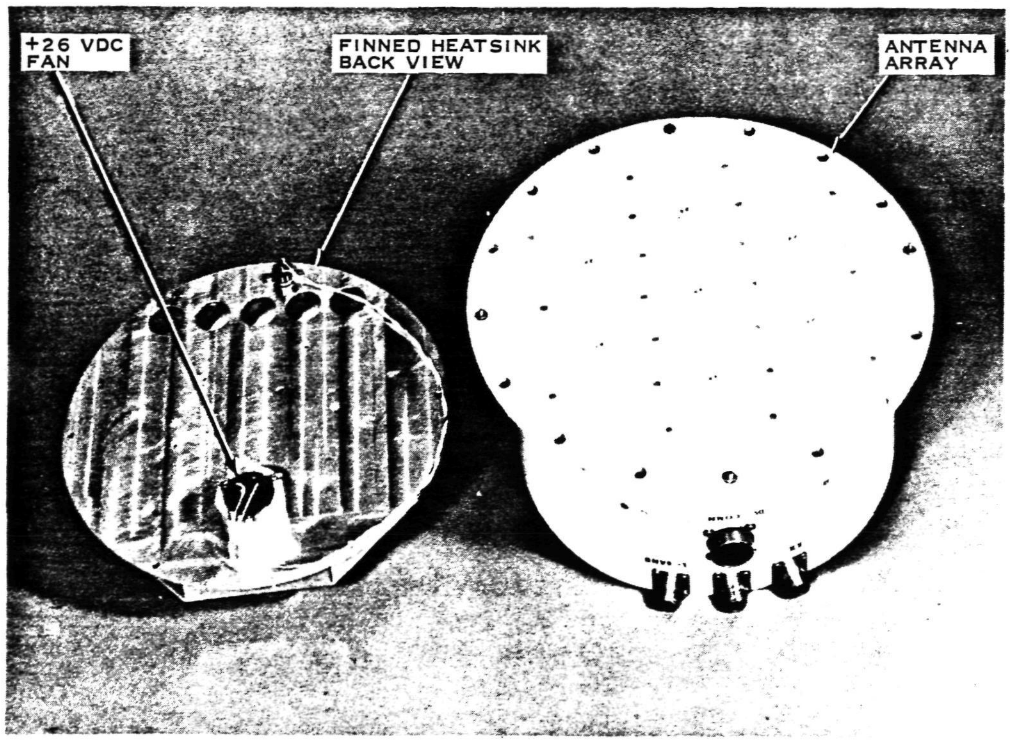


Figure 5-4. SPACS II Antenna Subsystem, Front View

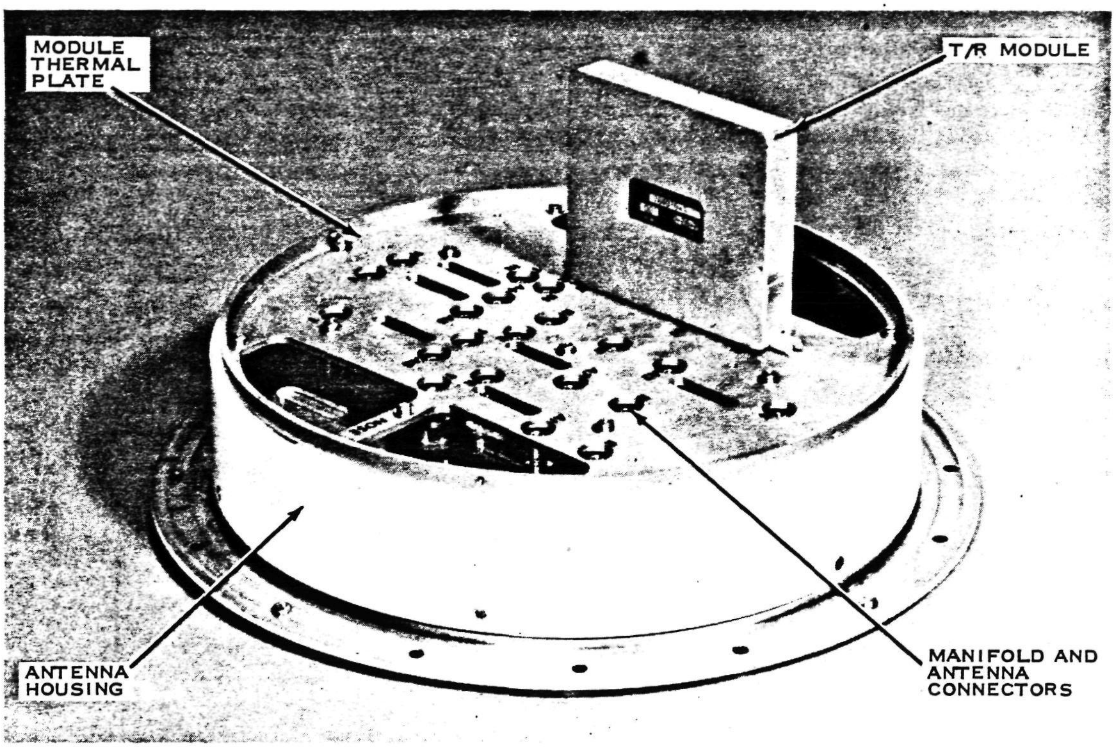


Figure 5-5. SPACS II Antenna Subsystem, Partially Assembled

ground plane (Figure 5-6) which was then attached to an antenna positioner on antenna range number 4 (Figure 5-7).

Standard microwave signal generators and amplifiers were used to drive the array and standard gain reference horns. The SPACS II array was powered from commercial power supplies located on the ground. The dc and logic signals were supplied to the array at the top of the positioner boom through a special 35-foot umbilical cord. The dc and logic signals were generated and controlled by two manual control boxes located on the ground.

The SPACS II antenna array subsystem was tested according to test procedure SKDD401 (Appendix E). Final data is summarized on the data sheets included in this appendix.

The four antenna array S-band transmit patterns for the subsystem are shown in Figure 5-8, the four S-band receive patterns are shown in Figure 5-9, and the four central (single) element L-band receive patterns are shown in Figure 5-10.

Table 5-1 contains a summary of these patterns. Compare these results with the array design goals listed in Table 2-1. The S-band transmitter EIRP design goals are 24 dBW on boresight and 18 dBW for 50- and 70-degree scan angles in the roll and azimuth planes respectively. The array comes very close to meeting these requirements within the measurement accuracy of the test equipment. The S-band receiver gain design goals are 31.5 dB on boresight and 25.5 dB at 50- and 70-degree scan angles in the roll and azimuth planes respectively. The array exceeds these goals by at least 8 dB. The L-band receive gain design goal was a 0-dB gain omni antenna followed by a 4-dB module loss and a 0.5-dB cable and connector loss. According to the data in Table 5-1, these figures are also very close to the design goals.

C. SUMMARY AND RECOMMENDATIONS

A review of the SPACS II antenna array subsystem antenna patterns and data shows that overall performance is good. The transmitter gain and EIRP values are very close to the design goals, and the receiver gain values greatly exceed the design goals. In general, array integration and tests went smoothly.

The following recommendations are suggested for future studies and tests on the array subsystem:

1. Obtain more antenna data at additional frequencies and planes of cut off the major axis.

2. Conduct antenna noise figure (or temperature) measurements.

3. Measure array dynamic steering performance. Look for changes in phase and amplitude performance.

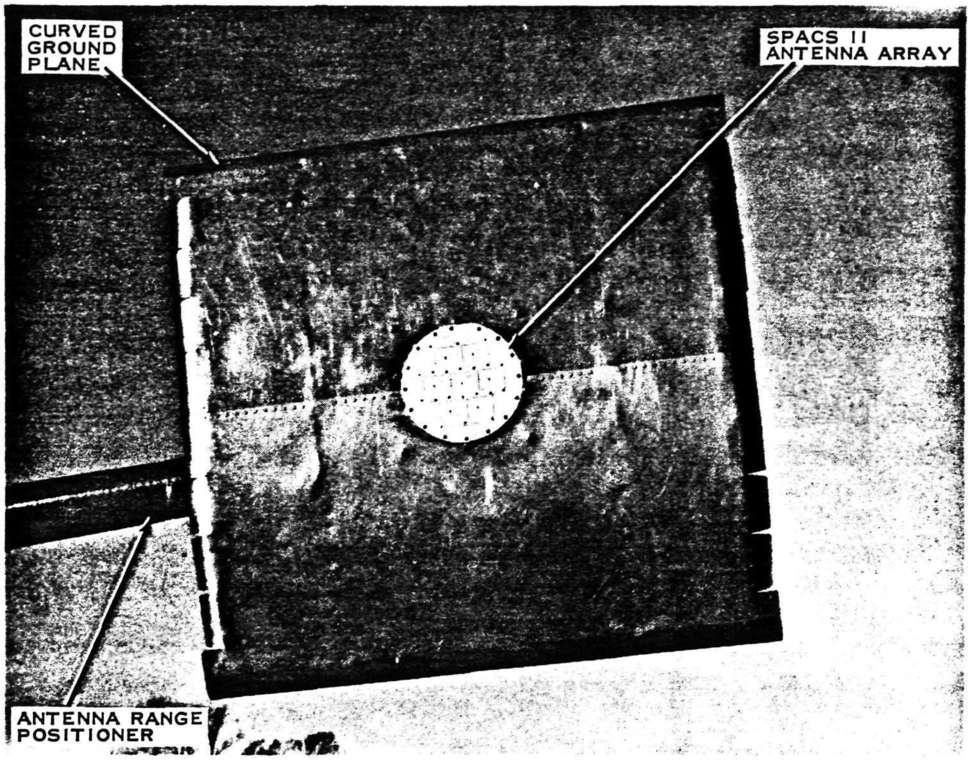


Figure 5-6. SPACS II Antenna Array Subsystem,
Mounted in Curved Ground Plane

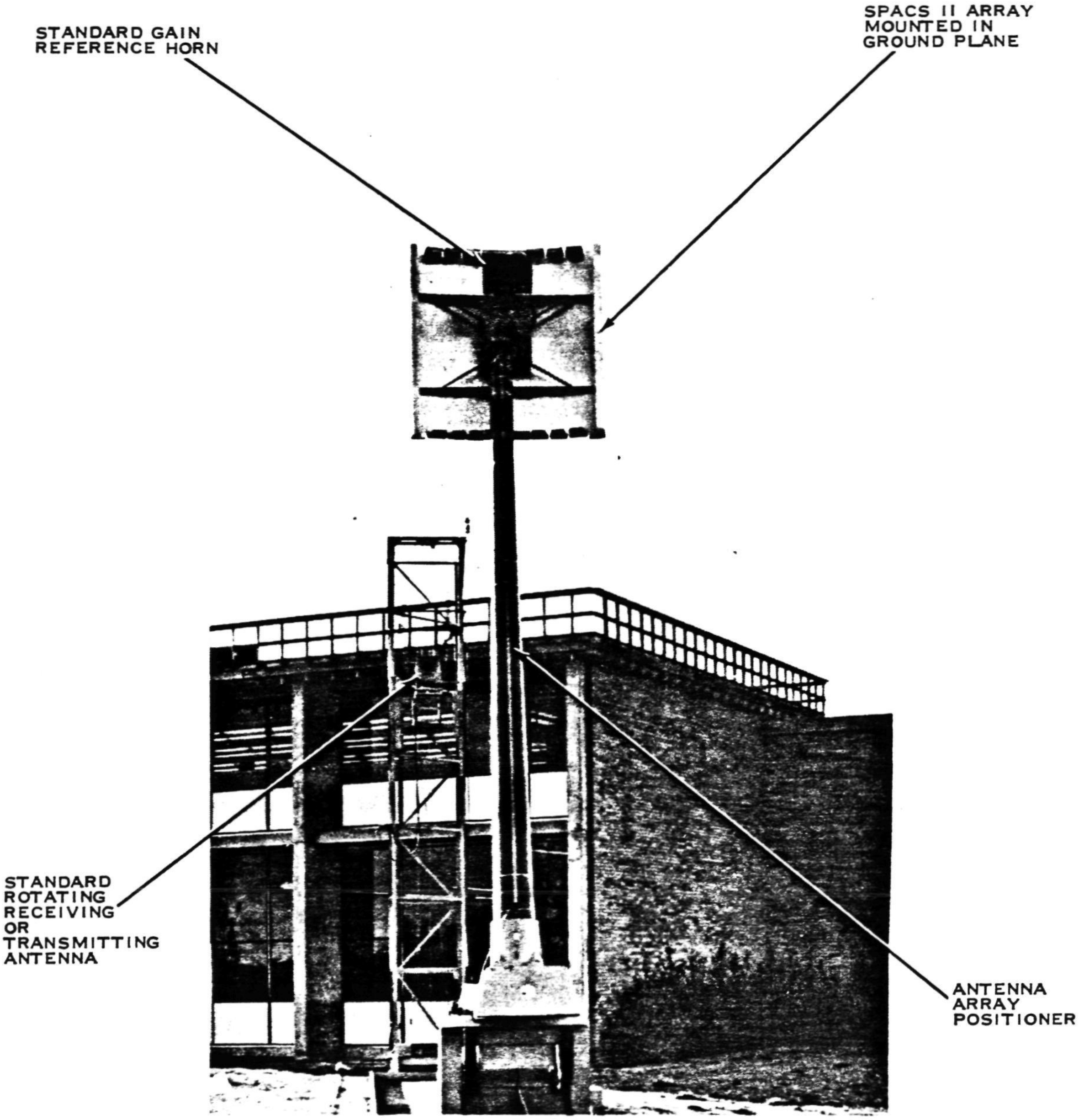


Figure 5-7. Antenna Range Number 4 with
SPACS II Antenna Array

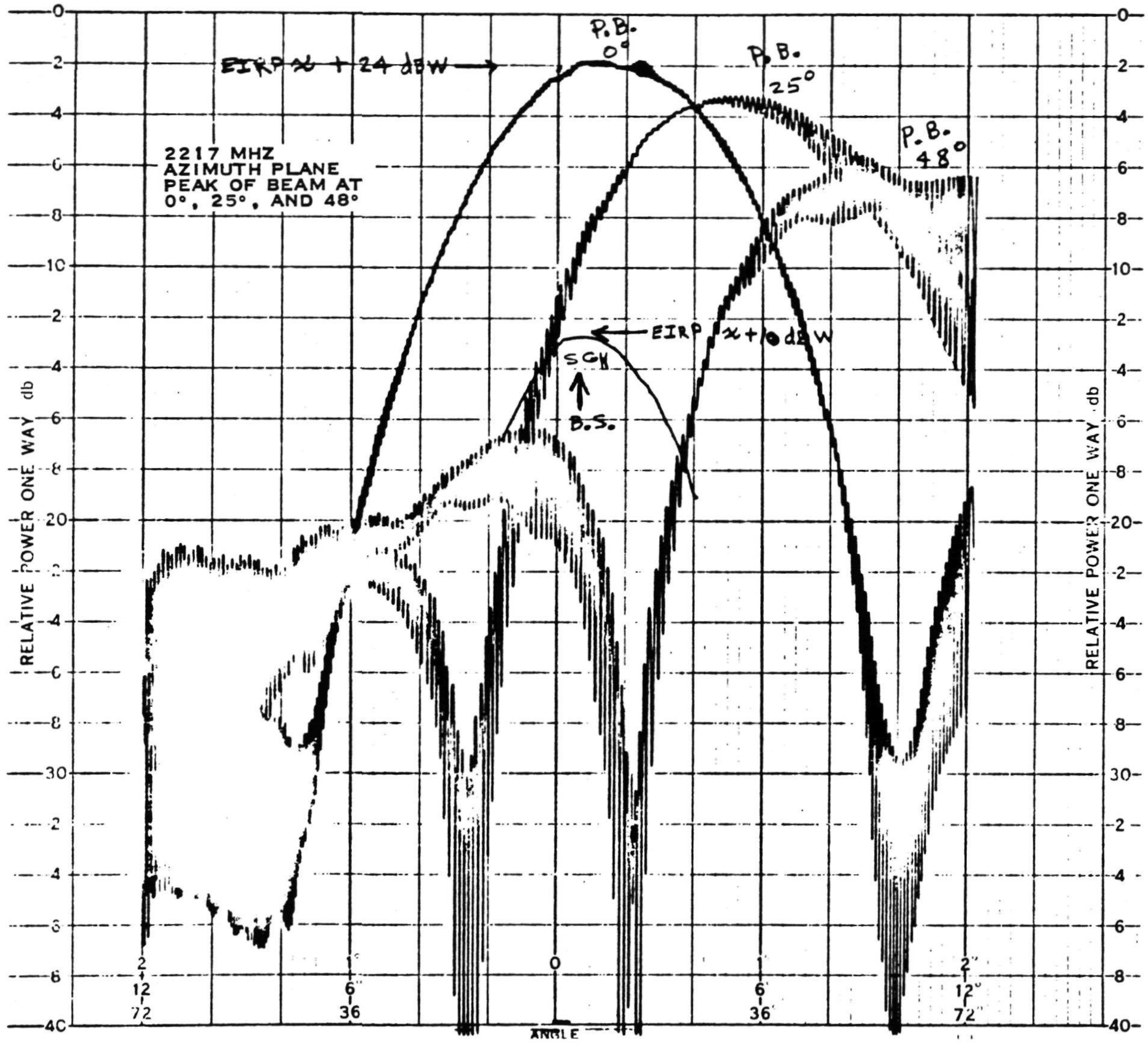


Figure 5-8. SPACS II Seven-Element Antenna Array
Subsystem Transmit Patterns
(Page 1 of 4)

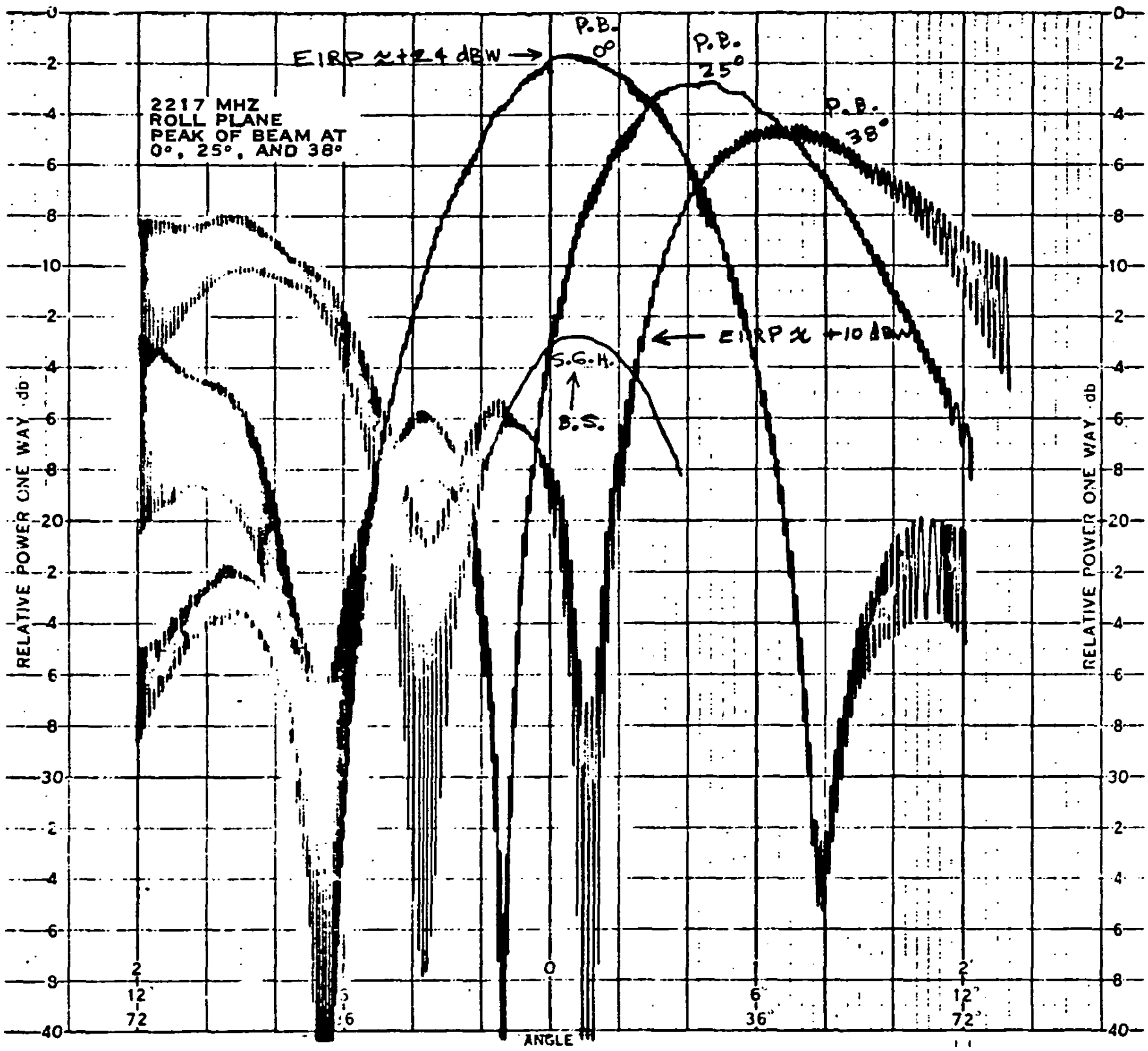


Figure 5-8. (Page 2 of 4)

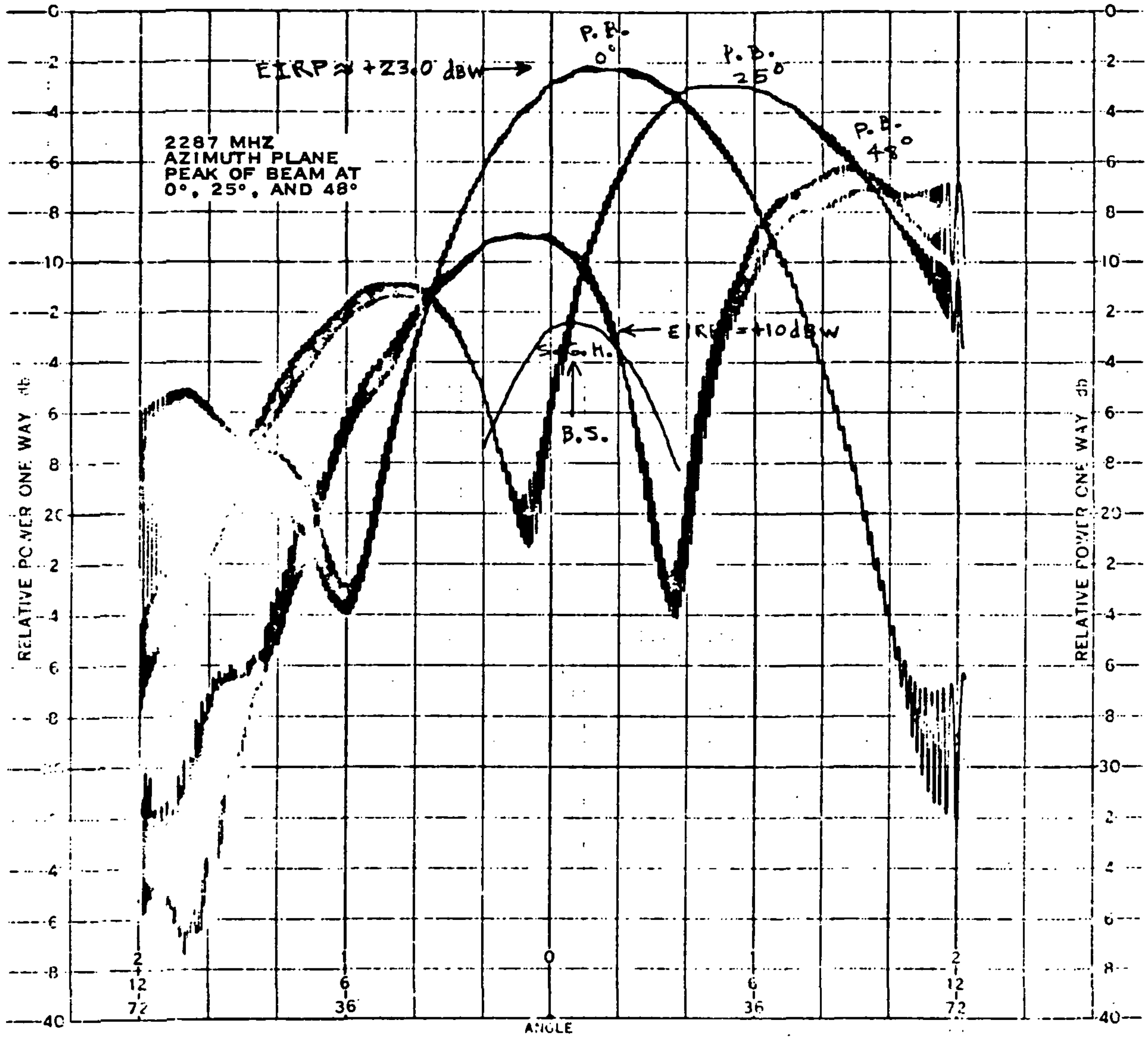
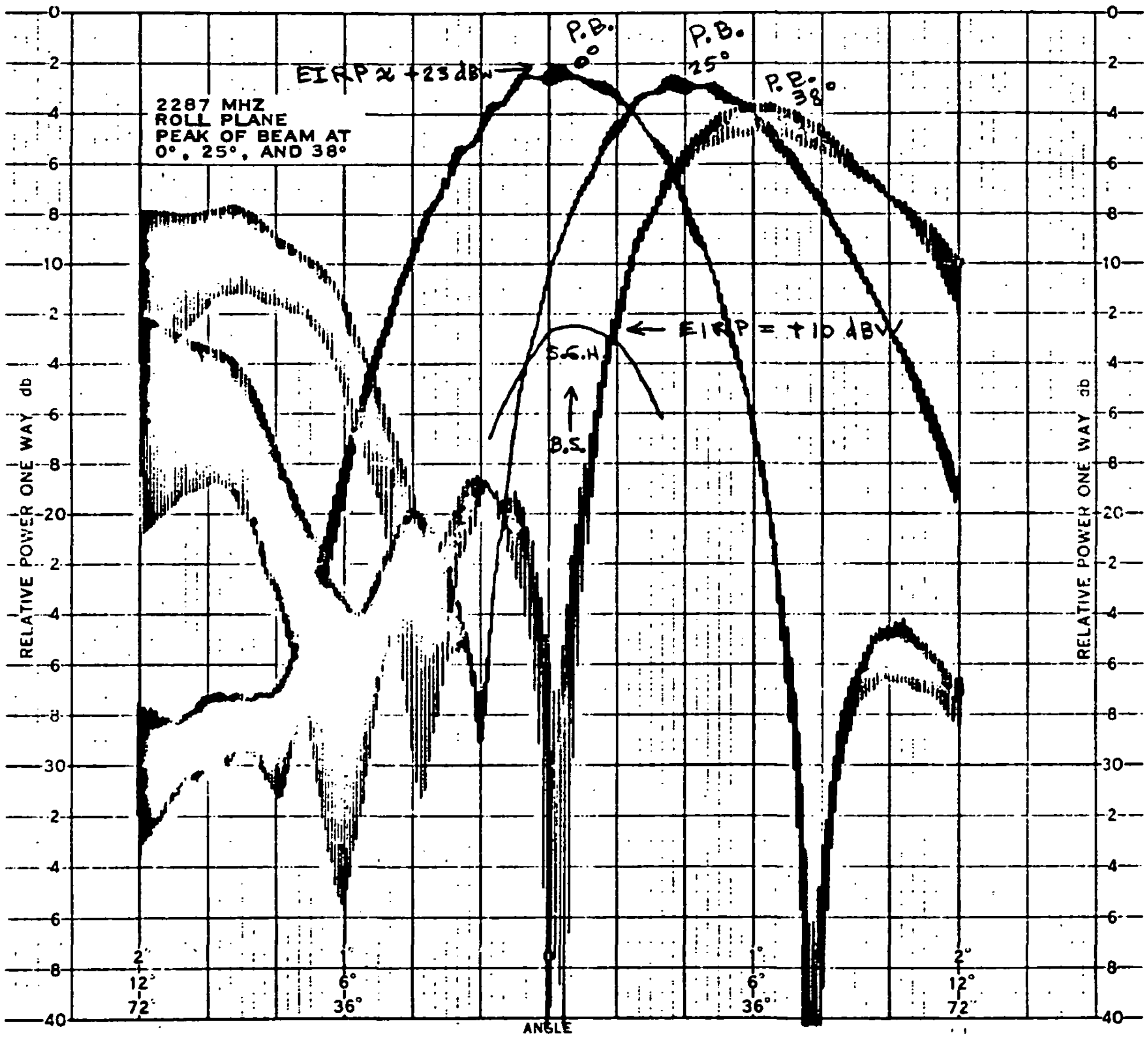


Figure 5-8. (Page 3 of 4)



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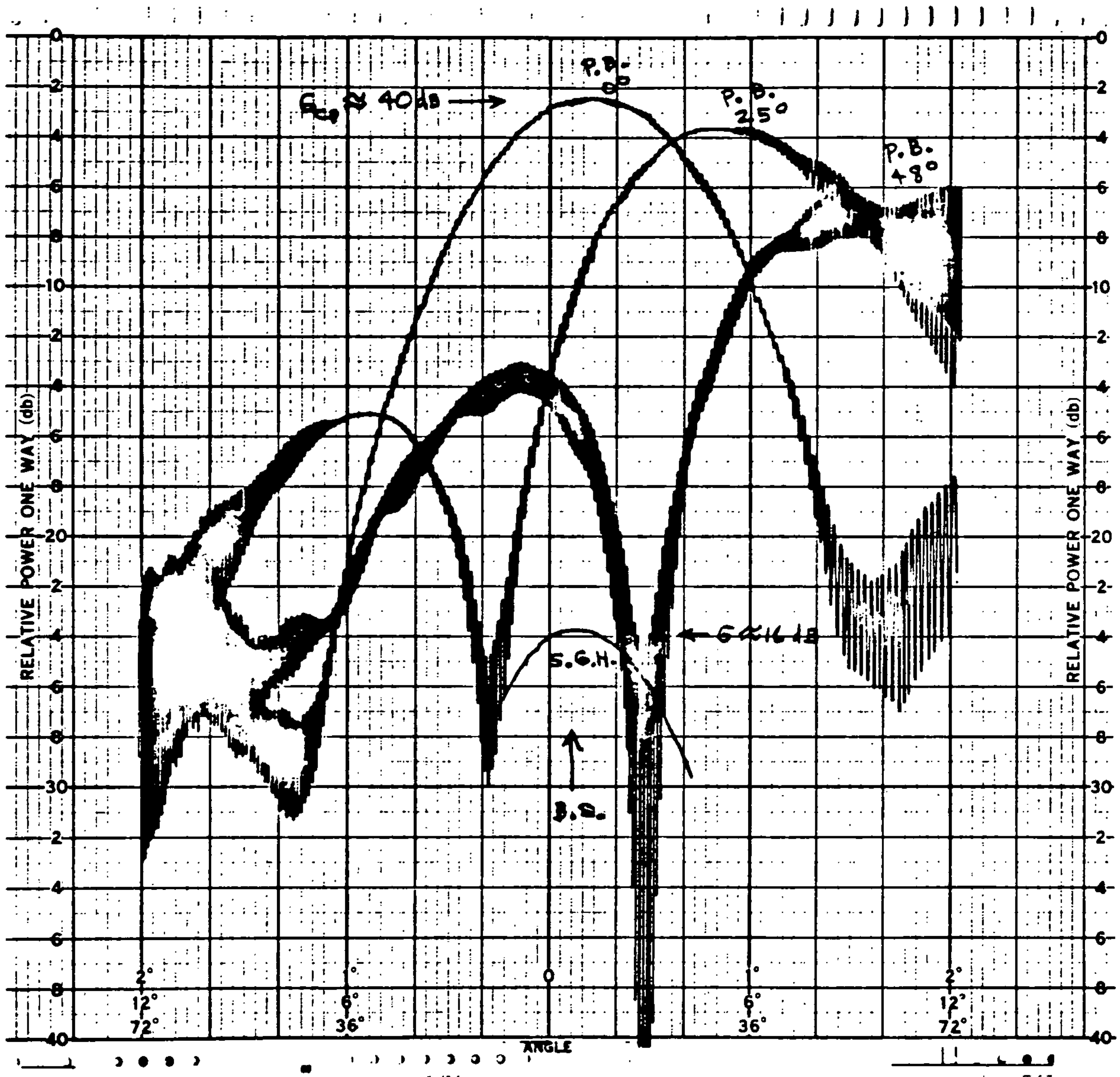
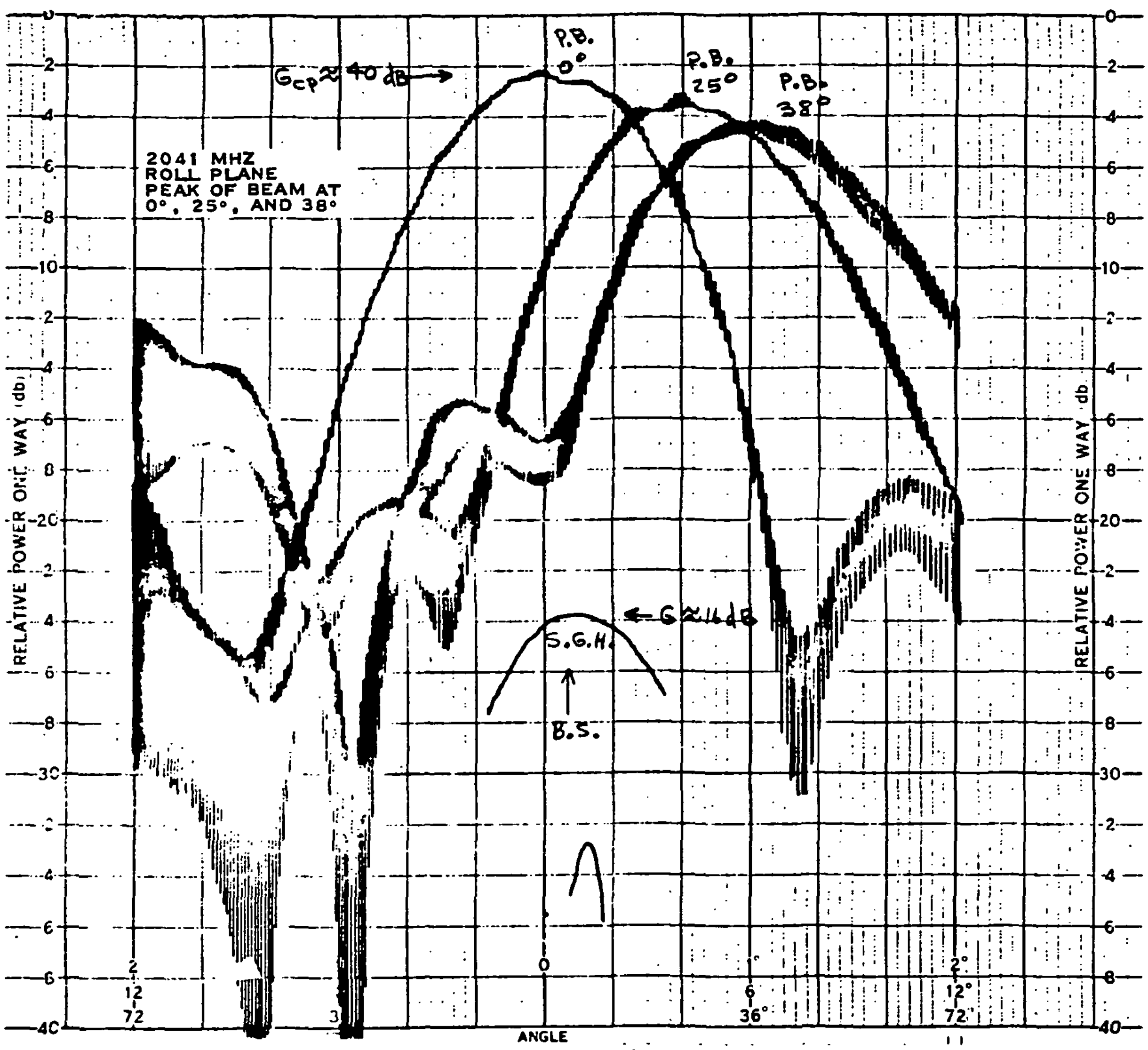


Figure 5-9. SPACS II Seven-Element Antenna Array Subsystem Receive Patterns (Page 1 of 4)



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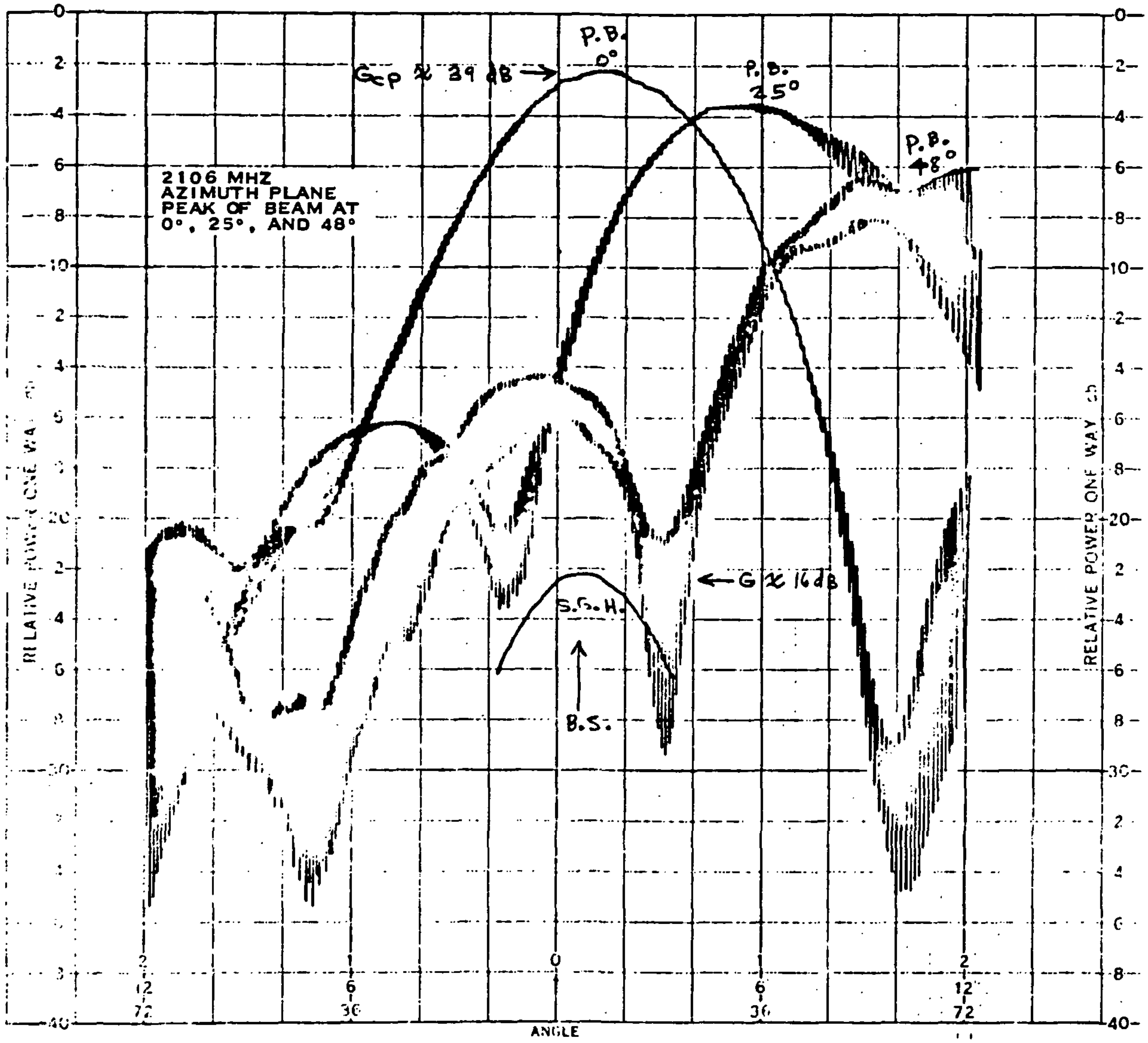

Figure 5-9. (Page 3 of 4)

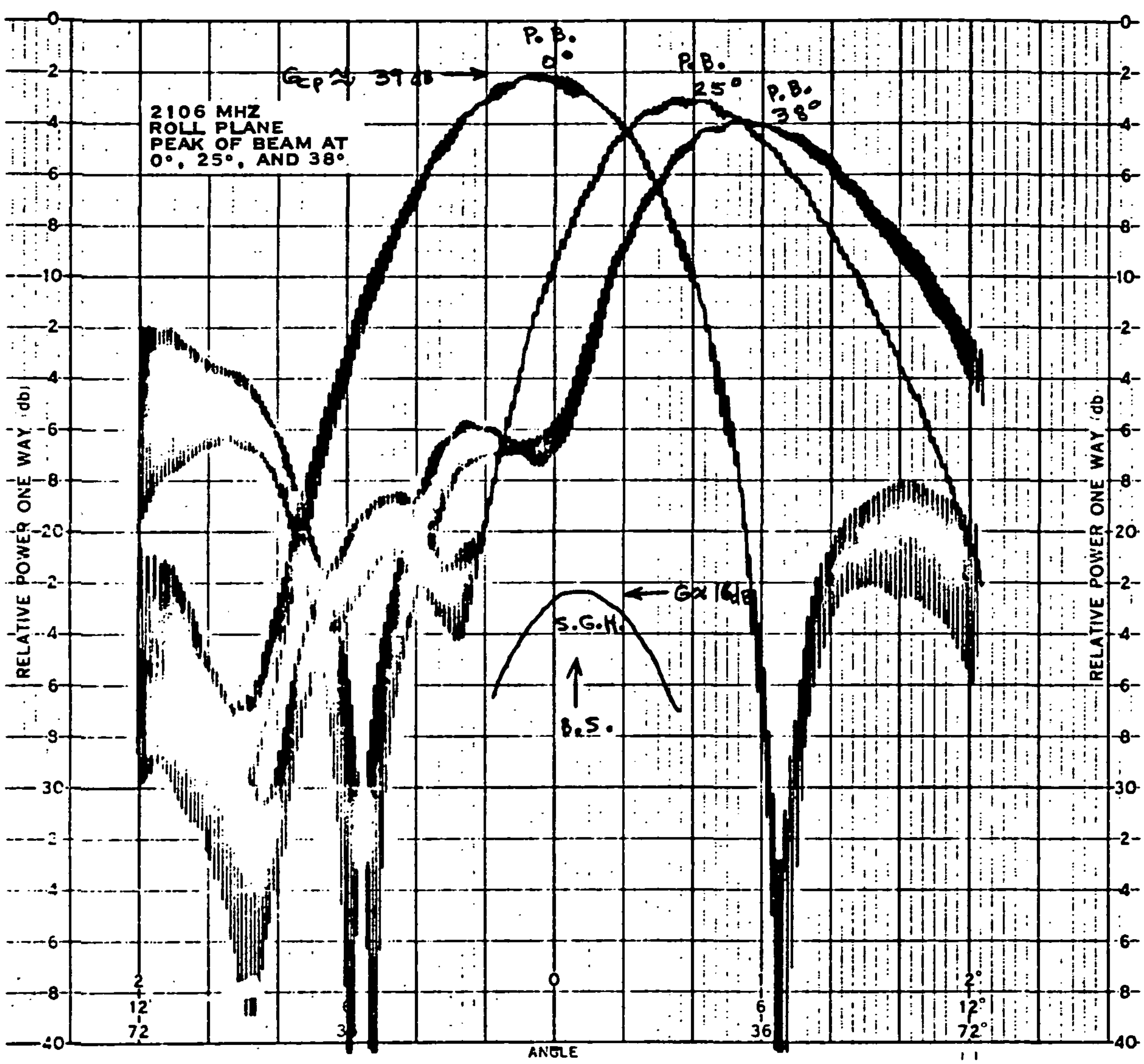

Figure 5-9. (Page 4 of 4)

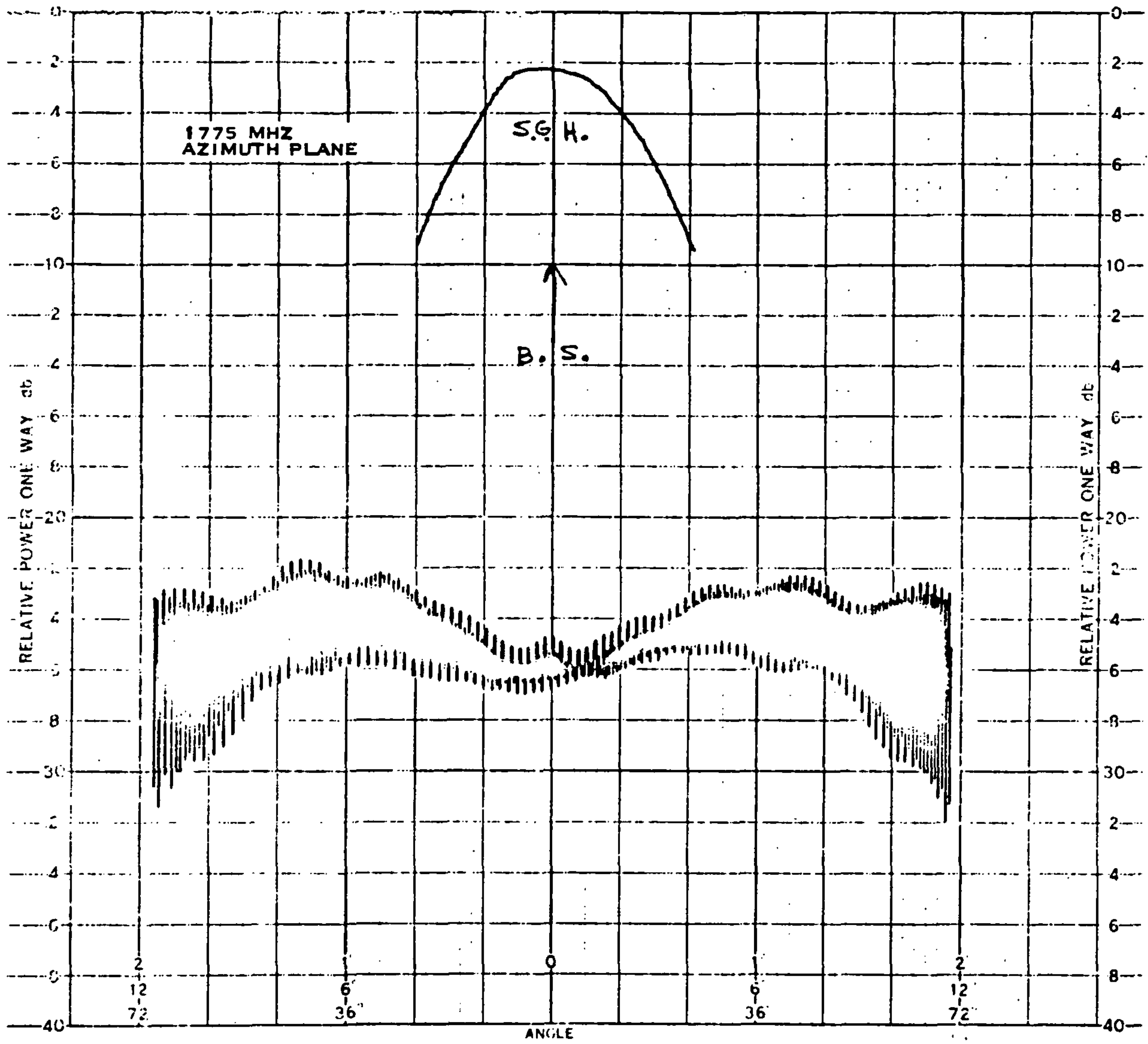

Figure 5-10. SPACS II Array, Central (Single)
Passive Antenna Element Receive Patterns
(Page 1 of 4)

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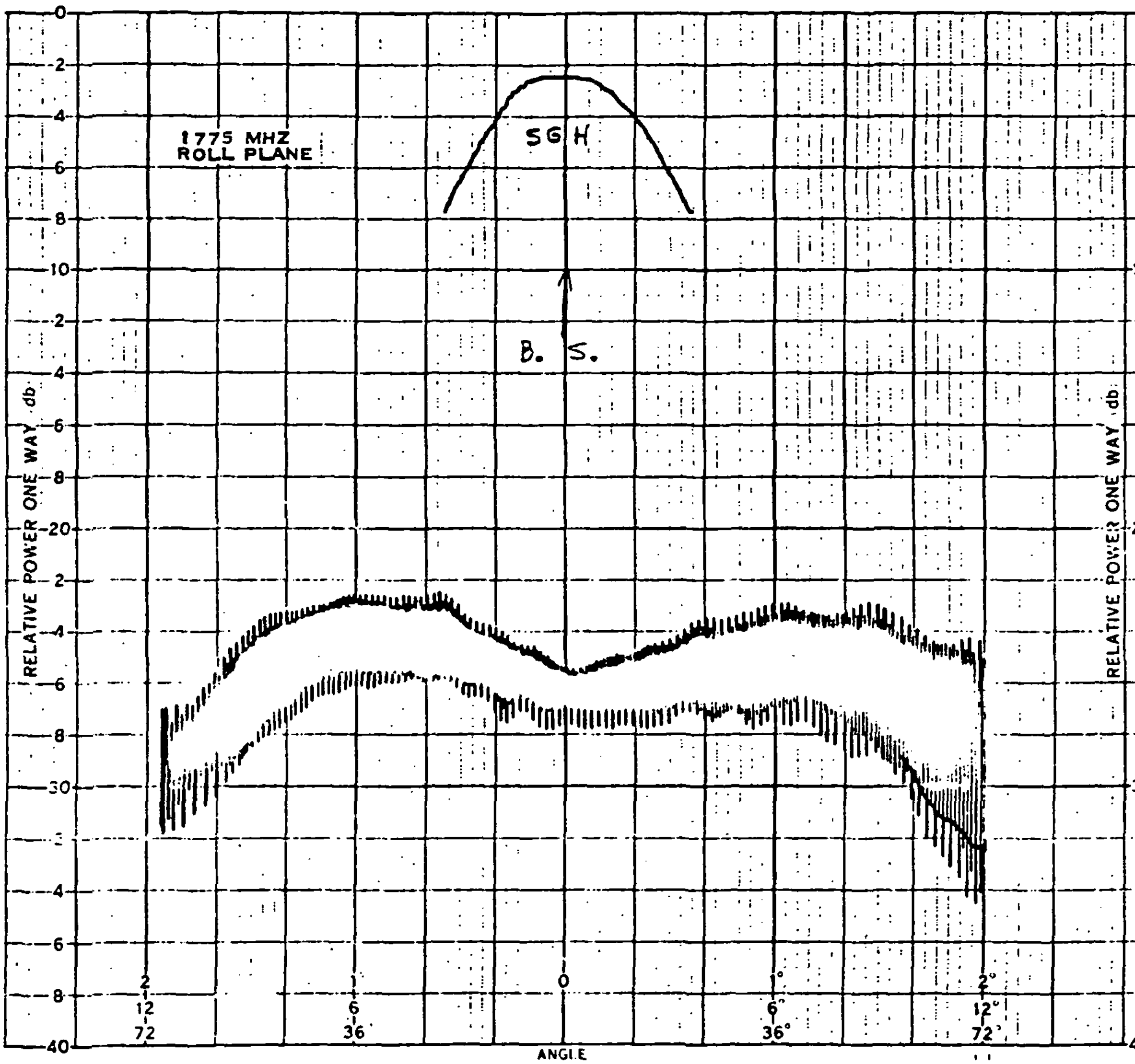

Figure 5-10. (Page 2 of 4)

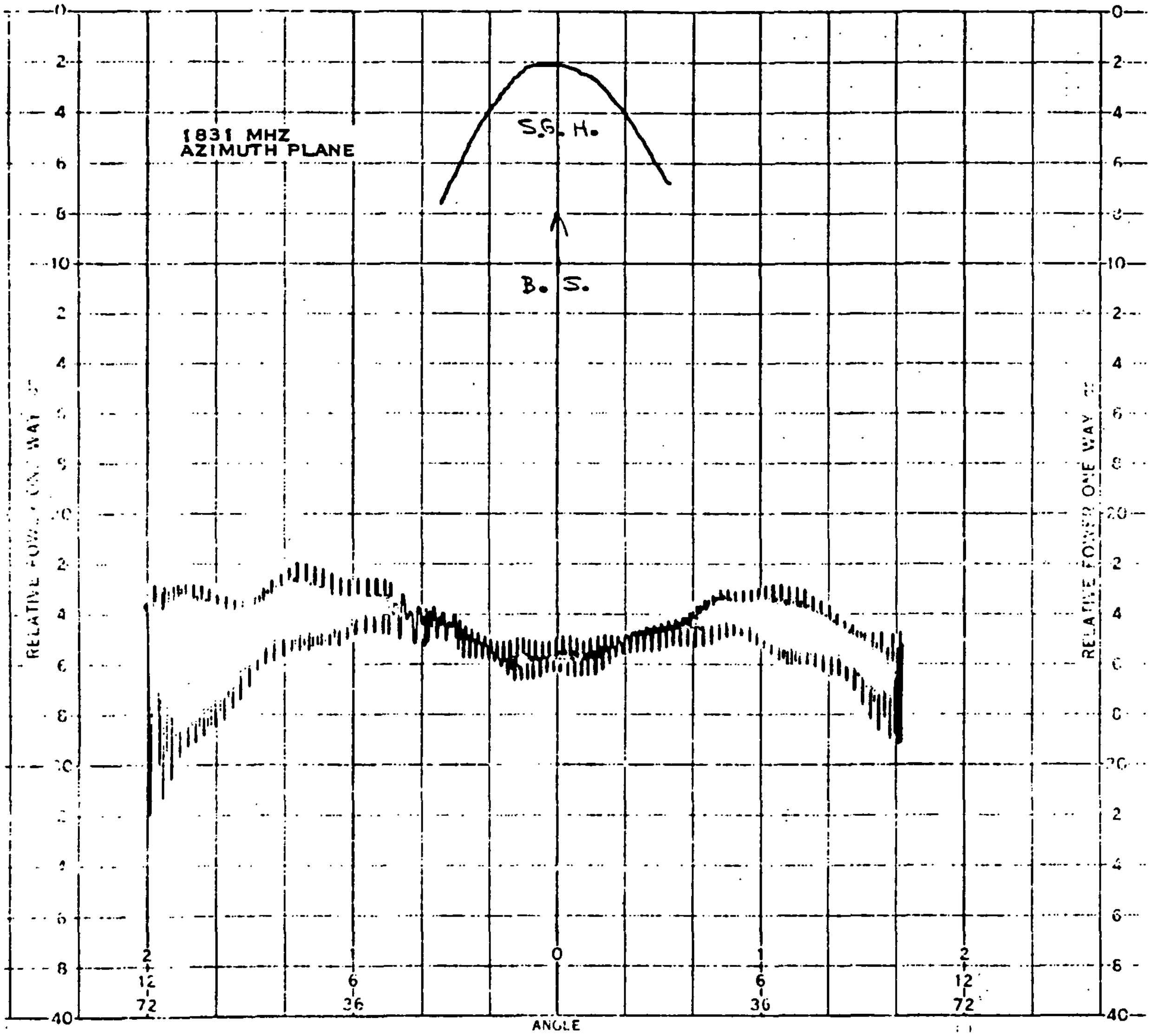

Figure 5-10. (Page 3 of 4)

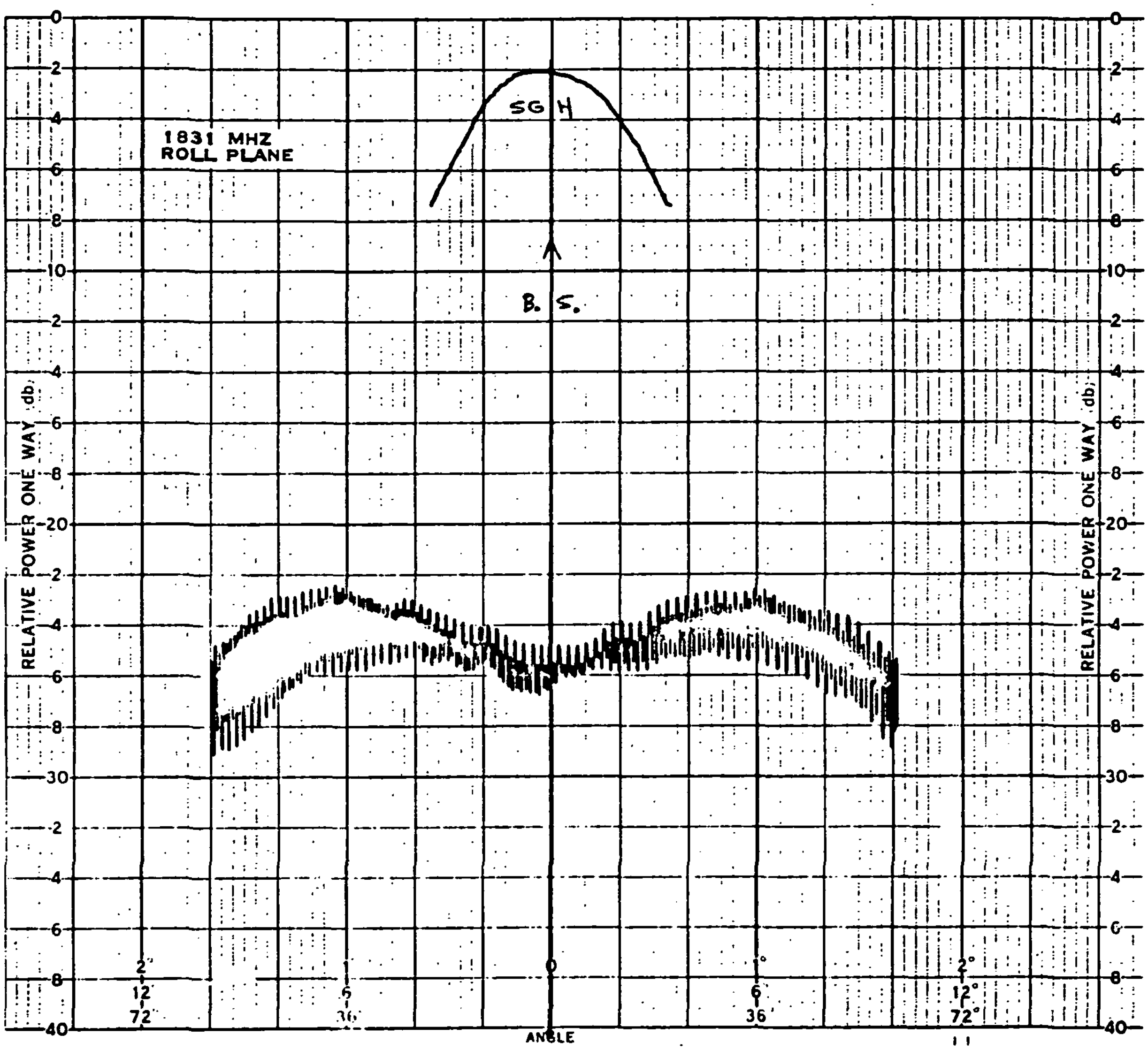

Figure 5-10. (Page 4 of 4)

Table 5-1. Summary of SPACS II Antenna Array Subsystem Performance

Frequency (MHz)	Plane of Cut	Scan Angle (degrees)	Gain G_{cp} (dB)	Transmit EIRP (dBW)
A. S-Band Transmit	Azimuth plane			
2217.5		0	30.0	23.5
2217.5		35	28.1	21.6
2217.5		70	24.0	17.5
2287.5		0	29.4	22.9
2287.5		35	28.4	21.9
2287.5		70	23.8	17.3
B. S-Band Transmit	Roll plane			
2217.5		0	30.2	23.7
2217.5		25	28.2	21.7
2217.5		50	26.5	20.0
2287.5		0	29.3	22.8
2287.5		25	28.6	22.1
2287.5		50	26.2	19.7
C. S-Band Receive	Azimuth plane			
2041.9		0	39.9	
2041.9		35	38.4	
2041.9		70	34.2	
2106.4		0	38.6	
2106.4		35	37.1	
2106.4		70	33.1	

Table 5-1. (Continued)

Frequency (MHz)	Plane of Cut	Scan Angle (degrees)	Gain G_{cp} (dB)	Transmit EIRP (dBW)
D. S-Band Receive	Roll Plane			
2041.9		0	39.7	
2041.9		25	38.6	
2041.9		50	36.2	
2106.4		0	38.3	
2106.4		25	37.9	
2106.4		50	34.6	
E. L-Band Receive	Azimuth plane			
1775.5		0	-5.5	
1775.5		35	-3.3	
1775.5		70	-5.0	
1831.8		0	-4.0	
1831.8		35	-3.5	
1831.8		70	-5.0	
F. L-Band Receive	Roll plane			
1775.5		0	-5.8	
1775.5		25	-4.2	
1775.5		50	-4.2	
1831.8		0	-6.5	
1831.8		25	-4.0	
1831.8		50	-4.3	

4. Find the optimum steering algorithms to reduce phase transients.

5. Experiment with the shuttle TPS material in front of the array to study any effects on gain, phase, and antenna patterns.

6. Transmit and receive phase-modulated signals through the array to study the effect of the array on signals.

7. Perform array receive experiments using spread spectrum signals to see the effects of the array.

SECTION VI

SUMMARY AND RECOMMENDATIONS

A. INTRODUCTION

This section summarizes the October 1975 status of the phased array development work for NASA Johnson Space Center under contract NAS9-14485. The example array application is the Space Shuttle Orbiter. The phased array development is known by the acronym SPACS which stands for S-band phased array communication system. SPACS was developed as a research program to improve the operation of the TDRSS to orbiter link and provide data with which to compare the baseline system. If adopted, it would be a part of the S-band network equipment.

The S-band communication system on the Space Shuttle is the voice and data link between the Shuttle and TDRSS (relay) satellite.

B. ENGINEERING MODEL SPACS II ANTENNA ARRAY SUBSYSTEM

The following list presents the four major tasks required by this contract:

1. Fabricate and test five outer modules identical to the one designed and built under NASA contract NAS9-14196.

2. Design, build, and test a center module with additional L-band receive capability and having no S-band transmit or receive phase shifters.

3. Design, build, and test a dc and logic multilayer manifold compatible with array and module requirements.

4. Integrate all hardware built under NASA contracts NAS9-14196 and NAS9-14485 into an antenna array subsystem and perform the major antenna tests on this subsystem.

All these tasks were completed and a summary of these tasks has been discussed in this report. Overall, the performance on these tasks was very good.

Table 6-1 shows an abbreviated description of the SPACS performance based on SPACS II measurements. Unlike a mechanically scanned antenna, the gain of an electronically scanned antenna varies with scan. The values of the figures of merit employed, EIRP, and gain noise temperature figure contain this variation and are stated as worst case values at the edge of coverage as well as at the broadside. Gains and module power outputs used in Table 6-1 were measured in August 1975 at Texas Instruments.

Table 6-1. Summary of SPACS II System Performance

Seven-element S-band antennas spaced at 90-degree intervals about the spacecraft (four)

Minimum EIRP over a 100 by 140 degree cone	17.5 dBW
Maximum EIRP at broadside	24 dBW
Input power level	30 dBm at switch input (1 watt)
Minimum gain/noise temperature over a 100 by 140 degree cone	-25 dB/°K
Maximum gain/noise temperature at broadside	-18 dB/°K
Receive electronic gain	30 dB
DC power	196 watts (22 to 30 volts), including steering controllers
Weight	17.0 pounds each array (four arrays)
Transmit frequencies	2217.5 and 2287.5 MHz
Receive frequencies	2041.9, 2106.4 MHz 1775.9, 1831.8 MHz
Dimensions	10.68-inch diameter by 7-inch height

Power conditioner/coordinate converter

Provides conditioned dc voltages to each array

Converts pointing angles for the system into array angles for correct phasing of modules

C. RISK AREAS AND IMPROVEMENTS

The only possible risk areas for a SPACS II array are thermal environment and vibration specifications. Under the thermal boundary conditions defined for the array in this contract, a low volume liquid loop from the vehicle is necessary to maintain the required temperature range of the array. With this liquid loop, all worst case missions can be met. If a liquid loop cannot be supplied, several worst case hot temperature conditions could not be met, but the majority of normal (nominal) flight missions could be met using an array self-contained liquid loop mounted to the bondline of the aircraft.

Further thermal definition and study should be conducted in coordination with NASA thermal designers to set all boundary conditions and thermal design methods. The thermal liquid loop is not a great risk, but more design work should be done to complete design details and control methods.

The vibration requirements during reentry and launch could be a problem depending upon the level of vibration and axis of vibration. The present SPACS II array is designed for use in fighter-type aircraft (MIL-E-5400 vibration specifications). Further study, definition, and design should be done to ensure the SPACS flight model meets all NASA shuttle vibration requirements. This does not appear to be a serious risk area.

Numerous improvements on the SPACS II breadboard mechanical, electrical and reliability performance can be made. It was not the intent of this research contract to build a flight-qualified item. Some areas for future improvements are reduced system weight, lower system power (higher efficiencies in module), lower system noise temperature, and increased antenna gain. All these areas can be improved with further work.

D. SUMMARY AND CONCLUSIONS

The initial work on this development was formulated in the fall of 1973 during a technical discussion at NASA Johnson Space Center. The contract known as SPACS I, NAS9-14196, was initiated in early summer of 1974 for development of the antenna, feed networks and prototype module. In early 1975, subsequent scope was added which called for the construction of additional modules. That additional scope is shown in the schedule in Table 6-2. This second contract (SPACS II, NAS9-14485) was completed in October 1975. A summary of the major antenna array subsystem performance for this contract is shown in Table 6-3.

The development of the SPACS array is an outgrowth of the technology developed for NASA MSFC under contract NAS8-25847 by Texas Instruments and the hardware under this MSFC contract was used to the maximum extent possible.

This SPACS II program was very successful and the majority of all design goals were met. The system design outlined and detailed in this final report appears to be a very competitive approach for the S-band communication system

Table 6-2. SPACS Contract Schedule

CURRENT STATUS (1 October 1975)

SPACS I Program

Developed and Tested

Seven-element antenna

RF feed networks

One breadboard outer module

Data

Monthly reports

Final report

New technology report

SPACS II Program

Developed and Tested

Development and delivery of one center module

Development and delivery of five additional outer modules

Development of a dc and logic manifold

Integration and testing of the antenna array subsystem

Schedule

Contract received	3 January 1975
Received all parts	15 May 1975
Completed module assembly and test	15 July 1975
Completed dc feed network	15 June 1975
Completed antenna subsystem tests	15 August 1975
Final report	15 October 1975

Data

Monthly reports

Final report

New technology report

Table 6-3. SPACS II Major Antenna Subsystem Parameters

Transmitter at 2217.5 MHz and 2287.5 MHz	
EIRP, minimum, 70- by 50-degree elliptical scan	17.5 dBW
EIRP Boresight	24 dBW
Gain (electronic)	22 dB minimum
Receiver at 2041.9 MHz and 2106.4 MHz	
Gain (electronic + antenna)	33 dB minimum
Noise figure (estimate)	6 dB nominal
Antenna Beamwidth	38 degrees (nominal)
L-Band Receive at 1775.5 MHz and 1831.8 MHz	
Center antenna gain	0 dB (nominal)
Module and cable loss	4 dB (nominal)
Array Body Diameter	10.68 inches maximum
Array thickness (including finned heatsink and fan)	7 inches
Weight	17 pounds nominal
DC power (total array)	+22 Vdc at 5.5 amperes maximum
	+12 Vdc at 0.4 amperes maximum
	+5 Vdc at 0.6 amperes maximum
	Total power input = 130 watts

for the Space Shuttle. In many areas, the SPACS system offers significant advantages over omni and passive phased array systems.

Areas for future development are a triplexer module, a steering (logic) controller, and dc power conditioner and coordinate converter unit. Texas Instruments will welcome the opportunity to expand the technical foundation laid in this effort. We are confident that continued development of the type of spacecraft antenna array described herein will lead to a useful flight subsystem applicable to a number of spacecraft uses including Space Shuttle, Space Tug, and Shuttle Payload experiments.

APPENDIX A

A-i

A

APPLICATION		REVISIONS			
NEXT ASSY	USED ON	LTR	DESCRIPTION	DATE	APPROVED
SK784010-1	1207				
SK446962-1	1207				

SPACS II - TRANSMIT/RECEIVE MICROELECTRONICS

MODULE TEST PROCEDURE FOR

OUTER MODULES (P/N SK784010-1) AND FOR

CENTER MODULES (P/N SK446962-1)

REF: NASA/JSC HOUSTON, TEXAS

CONTRACT: NAS9-14485

REV	
SHEET	
REV STATUS OF SHEETS	REV
	SHEET

UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES TOLERANCES ANGLES ±1° 3 PLACE DECIMAL ±.010 2 PLACE DECIMAL ±.02	DWN D. HARDISON DATE 5/7/75	TEXAS INSTRUMENTS INCORPORATED Equipment Group Dallas, Texas
IDENTIFYING NUMBERS SHOWN IN PARENTHESES FOR REFERENCE ONLY	CHK	
INTERPRET DWG IN ACCORDANCE WITH MIL-STD-100	ENGR D. Dehger 5-15-75	SPACS II - TRANSMIT/RECEIVE MICROELECTRONICS MODULE TEST PROCEDURE
	QA	
	APVD	
	CONTR NO	SIZE A · CODE IDENT NO 96214 · DRAWING NO SKDD301
	DESIGN ACTIVITY RELEASE	SCALE · SHEET 1 OF 15

TI-0023-C

SPACS II - TRANSMIT/RECEIVE MODULE TESTING

I. INTRODUCTION

The purpose of this document is to describe the test procedure for the SPACS II transmit/receive microelectronics module. This measured data is to be compared to the design parameters as defined in statement of work by paragraphs 3.1 through 3.2.2.5 of the contract NAS9-14485. A summary of these requirements is shown in the appendix of this test procedure.

II. MODULE TRANSMITTER TESTS

The transmitter side of the module will be tested using a Hewlett-Packard Automatic Network Analyzer (ANA) Model 8542A modified for high power measurements. The measurement will be controlled by a Texas Instruments developed software program (APAM1-1, Automatic Power Amplifier Measurement) based upon the HP8540 software series.

The test setup for this transmitter test is shown in Figure 1. An example ANA printout is shown by Figure 2. The device under test shown in Figure 1 will be the transmitter side of the SPACS II module.

In addition to the data shown by the printout of Figure 2, current on each of the power supply lines (+5V, +12V, and +22 volts) will be recorded from VOM readings at the minimum (0°) phase setting for each power level. A summary of this data will be recorded on the data sheets in SKDD302 labeled Table I. The data will be taken at room temperature (25°C) only.

III. MODULE RECEIVER TESTS

The receiver side of the module will be tested using a Hewlett-Packard Automatic Network Analyzer (ANA) Model 8542A under small signal conditions. The measurement will be controlled by a HP software program AGS03.

This measurement will use the same test setup as shown in Figure 1 with the exception of substitution of the HP 8746 Test Unit for the HP 8745 Test Unit. An example printout of the type of data measured is shown by Figure 3. The device-under-test shown in Figure 1 will be the receiver side of the SPACS II module.

In addition to the data shown by the printout of Figure 3, current on the power supply lines (+12V and +5 volts) will be recorded from VOM readings at the minimum (0°) phase setting. Power input to the antenna connector of the module will be -40 dBm to insure that the receiver amplifier is being operated in its linear (uncompressed) region.

A summary of this data will be recorded on the data sheet in SKDD302 labeled Table II. The data will be taken at room temperature (25°C) only.

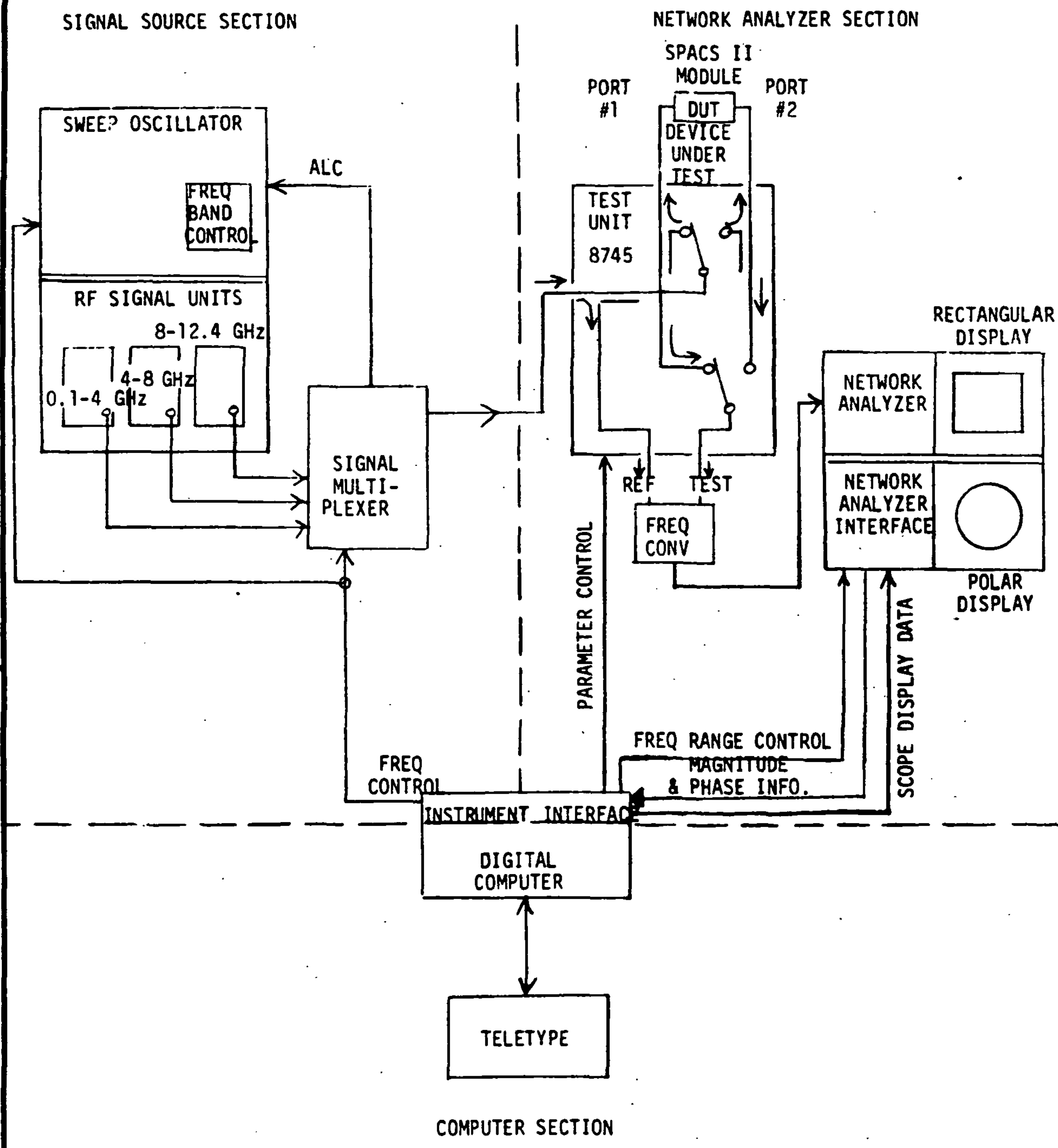

FIGURE 1. AUTOMATIC NETWORK ANALYZER SYSTEM (HP8542A)

SIZE	CODE IDENT NO	DRAWING NO
A	96214	SKDD301
SCALE	REV	SHEET 3

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A-3

TASK, TYPE? 2,1

INPUT POWER LEVEL CORRECTION FACTOR, ADD +6 DBM
GAIN CORRECTION FACTOR, ADD +23 DB
OUTPUT POWER CORRECTION FACTOR, ADD +29 DBM

NEW MEAS? Y

CONN DEVICE...0 DEGREES   SPACS II MODULE - TRANSMITTER SECTION

FREQ	REFL	VSWR	P IN	GAIN	PHASE	P OUT
			POWER LEVEL = 6.00 DBM			
2217.500	.108	1.241	6.00	.32	-91.8	6.32
2252.500	.215	1.549	5.97	1.41	75.5	7.37
2287.499	.382	2.235	5.98	-.23	-104.3	5.74
			POWER LEVEL = 7.00 DBM			
2217.500	.177	1.431	6.96	-.48	-89.3	6.48
2252.500	.165	1.395	7.01	.63	77.4	7.63
2287.499	.324	1.959	6.99	-.23	-110.8	6.76
			POWER LEVEL = 8.00 DBM			
2217.500	.238	1.626	8.01	-1.42	-97.3	6.59
2252.500	.180	1.438	7.99	-.23	78.6	7.75
2287.499	.259	1.699	7.96	-.76	-112.9	7.20

GRADE = 51.665

FIGURE 2. ANA PRINTOUT FOR TRANSMITTER MEASUREMENT (APAM1-1)

SIZE	CODE IDENT NO	DRAWING NO
A	96214	SKDD301
SCALE	REV	SHEET 4

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2,1

INPUT POWER = -40 DBM
GAIN CORRECTION FACTOR = ADD +30 DB

NEW MEAS? Y

CONN DEVICE...45 DEGREES   SPACS II MODULE-RECEIVER SECTION

FORWARD:

FREQ	REFL	ANGLE	RTN LS	VSWR	GAIN	PHASE	DELAY
2030.000	.521	114.6	5.7	3.171	4.59	-93.8	15.011
2041.000	.397	14.4	8.0	2.318	4.06	-153.2	14.193
2052.000	.292	-99.4	10.7	1.824	3.37	150.6	12.077
2063.000	.257	162.6	11.8	1.691	3.17	102.8	12.090
2074.000	.229	53.1	12.8	1.594	3.12	54.9	13.523
2085.000	.315	-68.2	10.0	1.918	3.25	1.3	13.540
2096.000	.450	-158.2	6.9	2.637	3.47	-52.3	13.713
2107.000	.483	110.8	6.3	2.866	3.44	-106.6	15.759
2117.999	.426	-6.7	7.4	2.486	3.55	-169.0	15.759

FIGURE 3. ANA PRINTOUT FOR RECEIVER MEASUREMENT (AGS03)

SIZE	CODE IDENT NO	DRAWING NO
A	96214	SKDD301
SCALE	REV	SHEET 5

TI-7915C

IV. RECEIVER NOISE FIGURE MEASUREMENT

The receiver side of the module will be tested using an AIL Model 75 Automatic Noise Figure Meter and an AIL Model 7010 Noise Generator. This will be a manual test using a calibrated test setup as shown in Figure 4.

This noise figure data will be recorded on the data sheet in SKDD302 labeled Table III. The data will be taken at room temperature (25°C) only. This data will be compared to module design goal of 4.87 dB noise figure; the maximum module noise figure requirement is 5.33 dB.

V. RECEIVER COMPRESSION POINT MEASUREMENT

The compression characteristic of the receiver will be tested using a manual calibrated setup as shown in Figure 5.

The 1 dB compression point will be measured and recorded on the data sheet for each of the frequencies shown in Table III of SKDD302. This compression data will be compared to the module design goal of +10 dBm at 1 dB compression point.

VI. MODULE DUPLEX OPERATION TEST

The test set shown in Figure 6 will be utilized to conduct an evaluation of the module in the fully duplexed mode. With the transmitter initially turned off, a spectrum analyzer is used to establish a -40 dBm receive signal (2041.9 MHz) at the module antenna port. The receiver output is then monitored and the output level is measured and recorded. When the transmitter is then enabled (2217.5 MHz) and operated into the 1.6:1 VSWR antenna load, the receiver output levels are again measured and recorded. Under duplex operation the receiver gain must be greater than 25 dB and there should be no more than 3 dB variation between gain with transmitter off and gain with transmitter on. The same test is repeated at the upper frequency band (transmit at 2287.5 MHz, receive at 2106.4 MHz). All this data will be summarized on the data sheet in SKDD302, Table IV.

An evaluation of intermodulation distortion will also be conducted under fully duplexed operation. The lower band test described above will be repeated with the 1.6:1 VSWR load replaced by a load VSWR less than 1.05:1. The module is fully duplexed and other frequency products will be observed to be greater than 40 dB below the receiver carrier frequency level. The 50 ohm load is replaced with the 1.6:1 VSWR mismatch and other frequency products will be observed to be greater than 20 dB below the receive carrier frequency. The intermodulation test will also be repeated at the upper frequency band (transmit at 2287.5 MHz, receive at 2106.4 MHz). No intermodulation products greater than 20 dB below the receive carrier frequency will be observed for either antenna port termination.

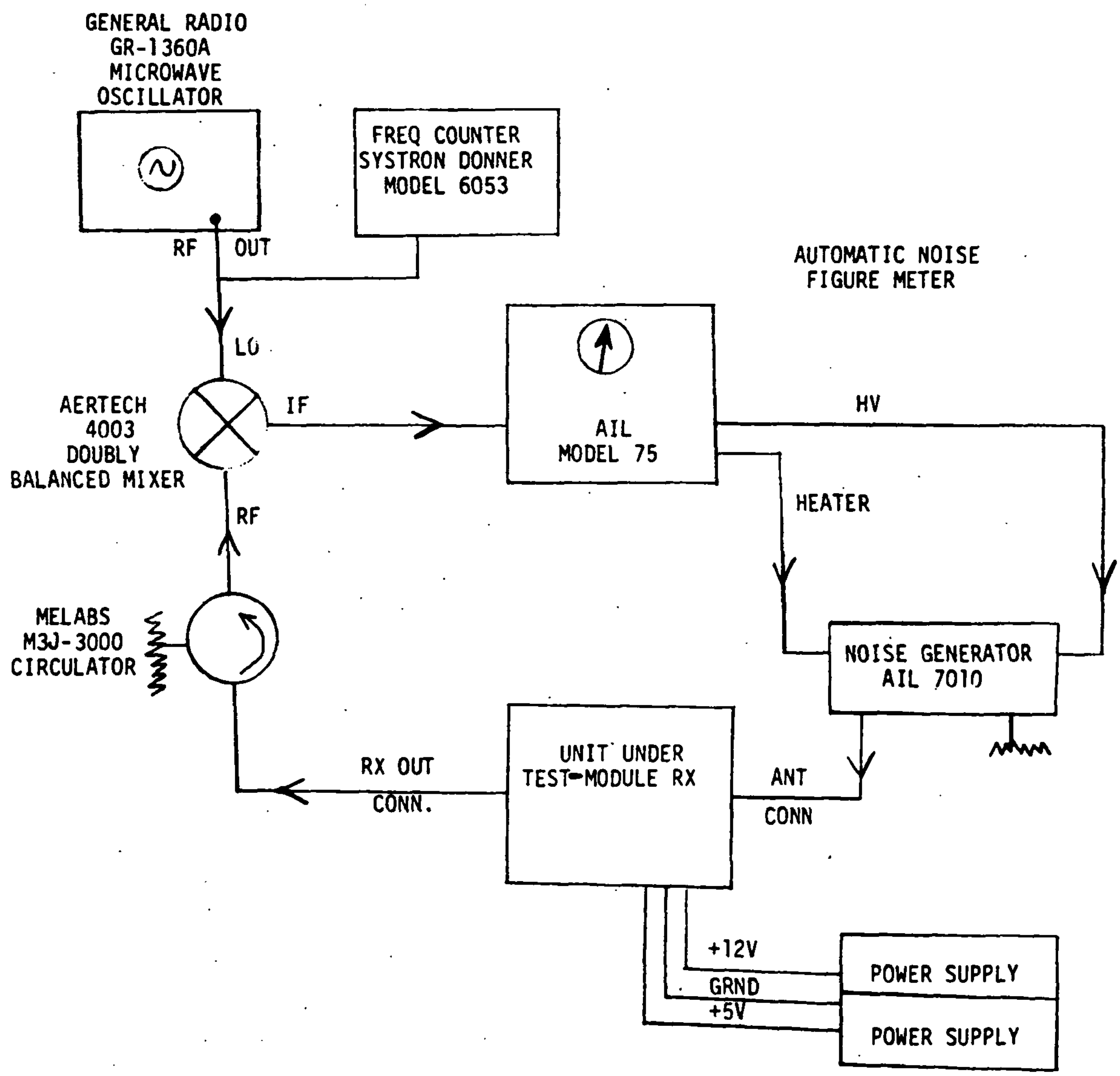

FIGURE 4. RECEIVER NOISE FIGURE TEST SETUP
(EQUIVALENT EQUIPMENT MAY BE
SUBSTITUTED)

SIZE	CODE IDENT NO	DRAWING NO
A	96214	SKDD301
SCALE	REV	SHEET 7

TI-7915C

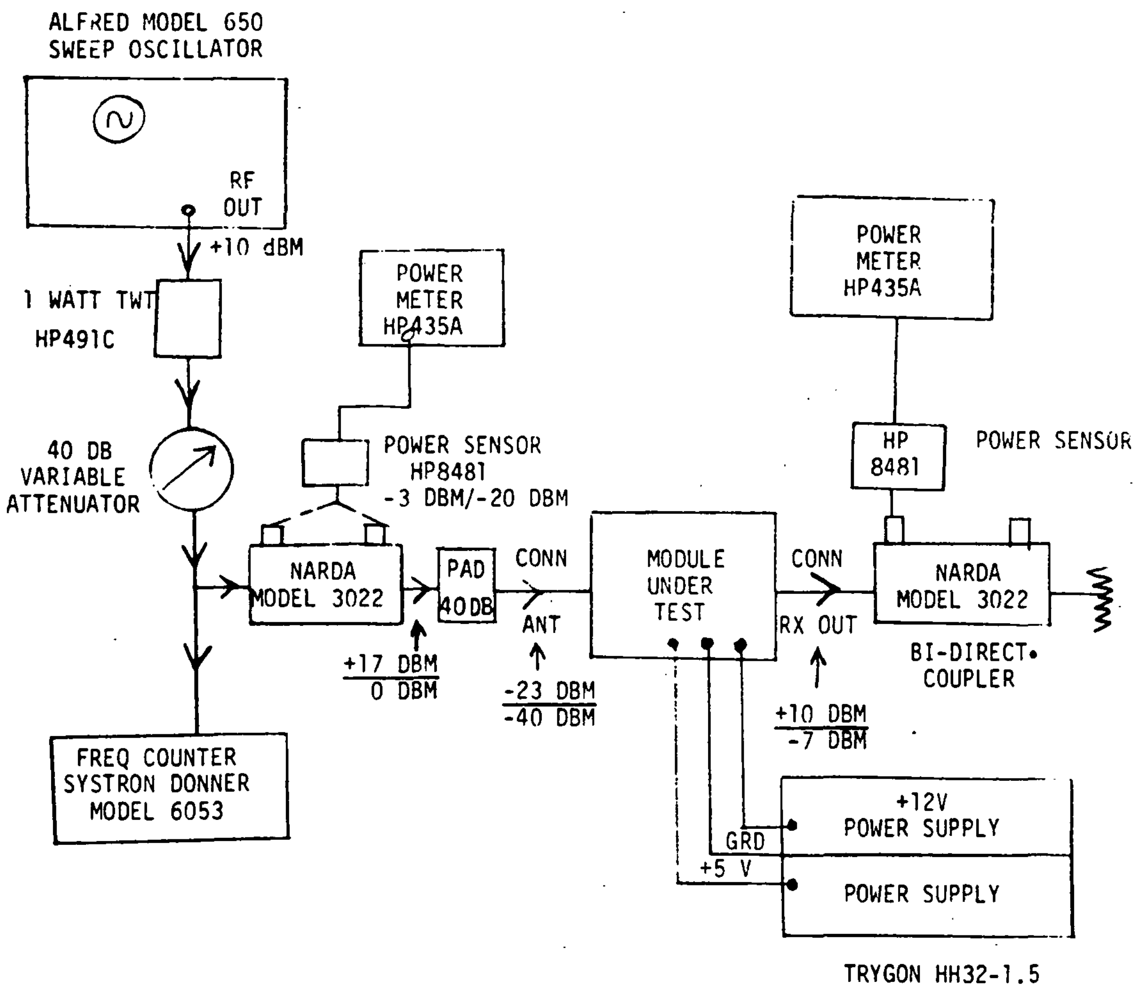

FIGURE 5. RECEIVER COMPRESSION (1 DB) POINT TEST SETUP
(EQUIVALENT EQUIPMENT MAY BE SUBSTITUTED)

SIZE	CODE IDENT NO	DRAWING NO
A	96214	SKDD301
SCALE	REV	SHEET 8

TI-7915C

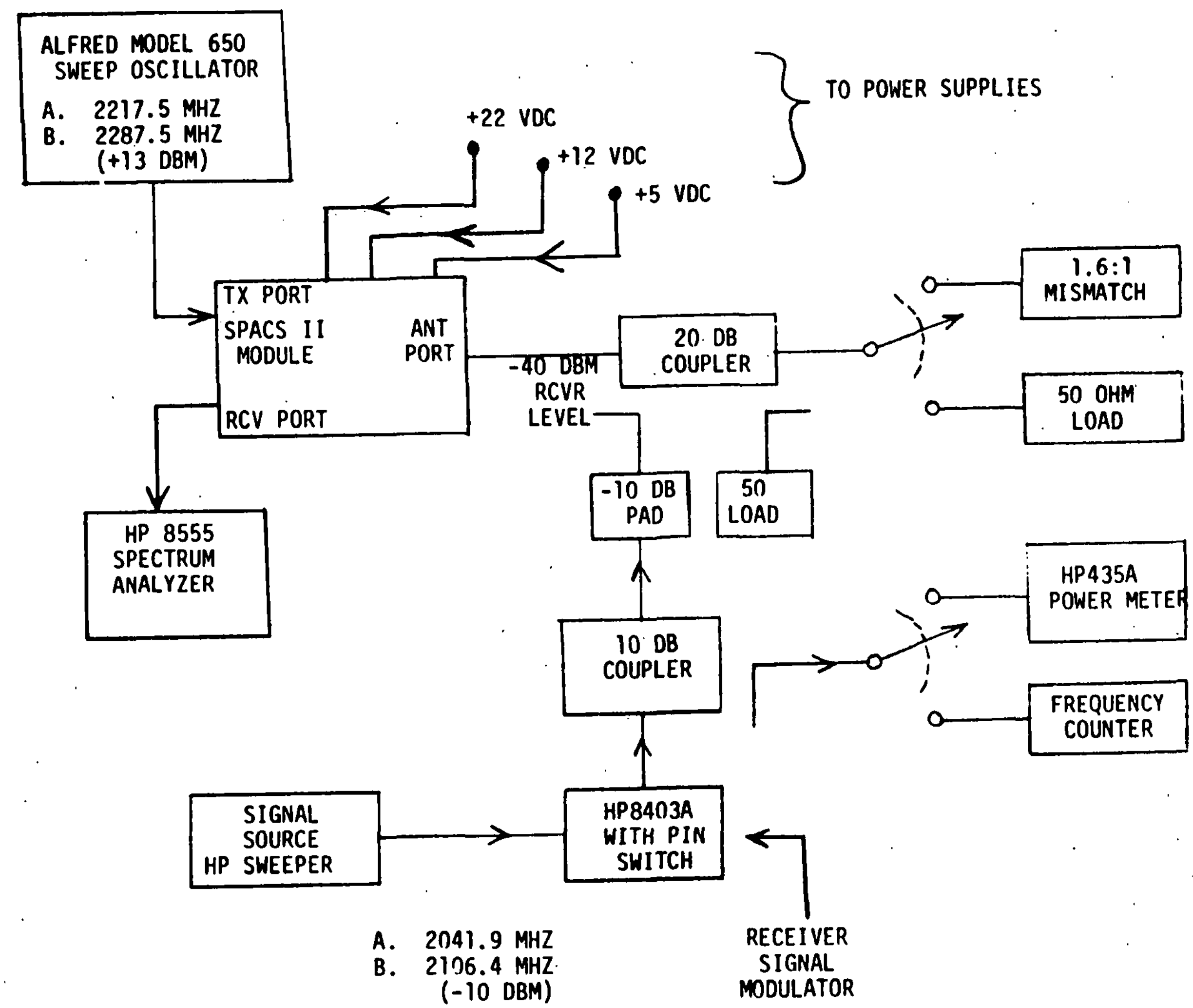

FIGURE 6. MODULE DUPLEX OPERATION TEST SETUP (EQUIVALENT EQUIPMENT MAY BE SUBSTITUTED)

SIZE	CODE IDENT NO	DRAWING NO
A	96214	SKDD301
SCALE	REV	SHEET 9

TI-7915C

A-9

The module will also be evaluated in the fully duplexed mode with pulsed modulation on the receive carrier frequency such that a sin x/x frequency spectrum is established with 4.6 MHz between second nulls. As viewed on a spectrum analyzer log display, no visible receiver distortion should occur for the transmitter-on under duplex operation. Pictures of these modulated receiver signals will be taken and attached to data sheets (SKDD302), Table V. These pictures will be at both receive frequencies with transmitter on and off. The only discernable change between transmitter on and off should be a drop in amplitude at all frequencies due to some receiver compression. This will not affect receiver performance.

VII. MODULE L-BAND OPERATIONAL TEST

This test applies only to those modules with L-Band receive capability (center modules, SK446962-1). The L-Band portion of the module will be tested using a Hewlett-Packard ANA Model 8542A under small signal conditions. The measurement will be controlled by a HP software program AG303.

This measurement will use the same test setup as shown in Figure 1 with the exception of the HP8746 test unit for the HP8745 test unit. The device-under-test will be the L-Band receive portion of the SPACS II module. Input power level will be -20 dBm.

A summary of this data will be recorded in Table VI. The transmission loss should be less than 4 dB at 1775.5 and 1831.8 MHz. This corresponds to a noise temperature of less than 440°K. Noise temperature will not be measured since all losses are ohmic and no active devices are located in this path.

APPENDIX

SIZE	CODE IDENT NO	DRAWING NO
A	96214	SKDD301

SCALE	REV	SHEET 11

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APPENDIX

TRANSMIT/RECEIVE MICROELECTRONICS MODULE
DESIGN SPECIFICATION

1.0 MODULE TECHNICAL REQUIREMENTS

1.1 Transmitter

1.1.1 Bandpass Characteristics

1.1.1.1 Center Frequency

The nominal center frequency shall be f_T=2252 MHz.

1.1.1.2 Bandpass

$\pm$ 55 MHz centered at f_T (1 dB - BW)

1.1.1.3 Bandshape

The bandshape shall be such that the output signal level described in paragraph 1.1.2.2.2 is achieved at each of the frequencies described in paragraph 1.1.2.1.1, and that the response $\pm$ 2304 KHz from either of the frequencies described in paragraph 1.1.2.1.1 varies less than 0.5 dB.

1.1.1.4 Response 100 MHz from Center of Bandpass

Attenuation at $\pm$ 100 MHz from f_T is more than 10 dB with respect to response at f_T.

1.1.1.5 Response 150 MHz from Center of Bandpass

Attenuation at $\pm$ 150 MHz from f_T is more than 20 dB with respect to response at f_T.

1.1.2 Signal Characteristics

1.1.2.1 Input Signal

1.1.2.1.1 Type

The input signal shall be a single angle modulated carrier operating at either one of two carrier frequencies, 2217.5 or 2287.5 MHz.

1.1.2.1.2 Modulation Width

The extent of the input signal spectrum shall be 2304 KHz from the carrier frequency to the second null of the spectrum.

1.1.2.1.3 Power Level

The input transmit signal at the input connector of each transceiver module shall be 13 dBm $\pm$ 1 dB.

1.1.2.2 Output Signal

1.1.2.2.1 Characteristics

The output signal shall be a replica of the single carrier input signal within the bandwidth of Paragraph 1.1.1.2.

1.1.2.2.2 Transceiver Module Power Output

The output power from each module at either frequency of Paragraph 1.1.2.1.1 will be no less than 35 dBm when terminated in a nominal 50 Ω load having a VSWR no greater than 1.5:1.

1.2 Receiver

The specifications for the receiver portion of the system are limited to the transceiver modules inasmuch as the system tests which validate the receiver performance are not included in this scope of work.

1.2.1 Bandpass Characteristics

The receiver has two frequency bands: one in S-band nominally centered at 2074 MHz (f_{RS}) and one in L-band nominally centered at 1804 MHz (f_{RL}). Only the center module will have an L-band frequency lead. The bandpass centered about the above center frequencies will be the following:

1.2.1.1 S-band Bandpass

87 MHz centered at f_{RS} (0.5 dB - BW).

1.2.1.2 L-band Bandpass

62 MHz centered at f_{RL} (0.5 dB - BW)

1.2.1.3 S-band Bandshape

The bandshape shall be such that the gain (described in Paragraph 1.2.2.2 and noise temperature described in Paragraph 1.2.2.4 shall be achieved at each of the S-band frequencies described in Paragraph 1.2.2.1) varies less than 0.5 dB.

1.2.1.4 L-band Bandshape

The bandshape shall be such that the loss described in Paragraph 1.2.2.3 and the noise temperature described in Paragraph 1.2.2.5 shall be achieved at each of the L-band frequencies described in Paragraph 1.2.2.1.1 and the response $\pm$ 2304 KHz from either of the L-band frequencies described in Paragraph 1.2.1.1 varies less than 0.5 dB. Only the center module has L-band capability.

1.2.1.5 Attenuation at $f_{RS} \pm$ 100 MHz from f_{RS} is no less than 15 dB with respect to carrier with 20 dB as a design goal.

1.2.1.6 Attenuation at $f_{RS} \pm$ 140 MHz from f_{RS} is no less than 40 dB with respect to the carrier with 45 dB as a design goal

1.2.1.7 Attenuation at $f_{RS} \pm$ 250 MHz from f_{RS} is no less than 60 dB with respect to the carrier.

1.2.2 Signal Characteristics

1.2.2.1 Input Signal

The input signal shall be a single angle modulated signal operating at a frequency of 2041.9, 2106.4, 1775.5 or 1831.8 MHz. The bandwidth of the L-band signal is at most $\pm$ 2.304 MHz from the carrier frequency to the second null. The S-band signal bandwidth when receiving from the ground system will be at most 4.6 MHz between second nulls. The S-band signal bandwidth when receiving from the Tracking and Data Relay Satellite shall be 22 MHz.

1.2.2.2 S-Band Receive Electronic Gain

The electronic gain to all signals in the S-band signal bandpass of Paragraph 1.2.1.1 shall be greater than 25 dB. This gain is measured from the antenna port of a single transceiver module to the S-band output port up to an output signal level of 0 dBm.

1.2.2.3 L-Band Electronic Loss

The L-band electronic loss shall be less than 4 dB between the antenna connector of the central module to the L-band output port.

1.2.2.4 Noise Temperature (S-band)

The S-band transceiver module noise temperature referenced to the module antenna connector shall be less than 700°K with a design goal of 600°K over any 10 MHz in the bandpass described in Paragraph 1.2.1.1 when terminated into a 50 ohm load at the S-band output connector.

1.2.2.5 Noise Temperature (L-band)

The L-band noise temperature of the S-band antenna subsystem referenced to the center module antenna connector shall be less than 440°K over any 10 MHz in the bandpass described in Paragraph 1.2.1.2 when terminated into a 50 ohm load.

1.3 Suitable Module Temperature Range

To meet all module power, gain, noise figure and phase requirements, the maximum module case temperature range is 0°C to +45°C.

APPENDIX B

APPLICATION	
NEXT ASSY	USED ON
SK784010-1	1207
SK446962-1	1207

REVISIONS			
LTR	DESCRIPTION	DATE	APPROVED

SPACS II - TRANSMIT/RECEIVE MICROELECTRONICS MODULE

MEASUREMENT DATA SHEETS FOR OUTER MODULES

(P/N SK784010-1) AND FOR CENTER MODULES

(P/N SK446962-1)

REF: NASA/JSC HOUSTON, TEXAS

CONTRACT: NAS9-14485

A/T Final Data: 7-15-75

MODULE PART NUMBER SK784010-1
(RECORD)

MODULE SERIAL NUMBER 001
(RECORD)

DRD

REV																														
SHEET																														
REV STATUS OF SHEETS	REV																													
	SHEET																													

UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES TOLERANCES ANGLES ±1° 3 PLACE DECIMAL ±.010 2 PLACE DECIMAL ±.02	DWN P. Harrison DATE 5-9-75	TEXAS INSTRUMENTS INCORPORATED Equipment Group Dallas, Texas
	CHK	
IDENTIFYING NUMBERS SHOWN IN PARENTHESES FOR REFERENCE ONLY	ENGR P. Peder 5-15-75	SPACS II-TRANSMIT/RECEIVE MICROELECTRONICS MODULE MEASUREMENT DATA SHEETS
	QA	
INTERPRET DWG IN ACCORDANCE WITH MIL-STD-100	APVD	
	CONTR NO	SIZE A · CODE IDENT NO 96214 · DRAWING NO SKD0302
	DESIGN ACTIVITY RELEASE	
		SCALE · SHEET 1 OF 12

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TABLE I. SPACS II MODULE RECORDED TRANSMITTER DATA
(ROOM TEMPERATURE ONLY)

INPUT POWER LEVEL = +12 DBM

FREQUENCY MHZ	COMMANDED PHASE SETTING DEGREES	MEASURED ** PHASE SETTING DEGREES	Δφ	INPUT VSWR	POWER OUTPUT DBM	GAIN DB	POWER SUPPLY* CURRENTS MA
2217.5	0	81.8	Ref.	1.213	34.86	22.89	I_{5V} = 76
	45	44.4	37.3	1.131	34.82	22.86	
	90	-4.6	86.3	1.534	34.88	22.92	I_{12V} = 40
	135	-34.5	116.2	1.430	35.14	23.15	
	180	-106.3	188.0	1.145	34.89	22.92	
	225	-137.8	219.5	1.104	35.03	23.07	I_{22V} = 925
	270	171.5	270.2	1.147	35.23	23.26	
	315	135.7	303.0	1.057	35.12	23.16	
2257.5	0	-127.9	Ref.	1.678	35.99	24.01	I_{5V} = 76
	45	-166.9	39.0	2.052	35.54	23.57	
	90	144.1	82.2	1.459	35.76	23.78	I_{12V} = 41
	135	105.8	126.3	1.256	36.20	24.22	
	180	50.1	182.0	1.424	36.41	24.41	
	225	17.1	215.0	1.324	36.13	24.15	I_{22V} = 950
	270	-32.0	264.1	1.283	36.06	24.08	
	315	-82.9	315.0	1.679	35.97	24.00	
2287.5	0	84.8	Ref.	2.232	35.03	23.03	I_{5V} = 76
	45	51.7	33.1	2.405	34.58	22.58	
	90	-4.1	88.9	1.148	35.41	23.41	I_{12V} = 40
	135	-43.6	128.4	1.527	35.12	23.12	
	180	-99.0	183.8	1.821	35.45	23.45	I_{22V} = 740
	225	-132.0	216.8	1.913	34.98	22.98	
	270	171.2	273.5	1.434	35.51	23.51	
	315	137.4	307.4	1.789	35.01	23.01	

*Current measured at 0° phase setting only.

**Only 0° setting is measured on center modules (P/N SK446962-1)

SIZE	CODE IDENT NO	DRAWING NO
A	96214	SKKDD302

SCALE | REV | SHEET 2

TI-7915C

TABLE I. SPACS II MODULE RECORDED TRANSMITTER DATA (CONTINUED

INPUT POWER LEVEL = +13 DBM

FREQUENCY MHZ	COMMANDED PHASE SETTING DEGREES	MEASURED ** PHASE SETTING DEGREES	Δφ	INPUT VSWR	POWER OUTPUT DBM	GAIN DB	POWER SUPPLY* CURRENTS MA
2217.5	0	84.0	Ref.	1.427	34.81	21.83	I_{5V} = 76
	45	48.1	35.9	1.121	34.69	21.72	
	90	-6.2	90.2	1.538	34.92	21.95	I_{12V} = 40
	135	-36.0	120.0	1.542	35.11	21.14	
	180	-106.0	190.0	1.310	34.94	21.96	I_{22V} = 945
	225	-138.3	222.3	1.124	35.08	22.11	
	270	168.4	275.6	1.228	35.28	22.31	
	315	137.3	306.7	1.121	35.11	22.13	
2257.5	0	-126.6	Ref.	1.520	36.00	23.01	I_{5V} = 76
	45	-169.4	42.8	1.639	35.73	22.78	
	90	148.1	85.3	1.202	35.85	22.85	I_{12V} = 41
	135	102.8	130.6	1.171	36.26	23.26	
	180	53.3	180.1	1.157	36.47	23.47	I_{22V} = 930
	225	9.1	224.3	1.142	36.52	23.52	
	270	-33.1	266.5	1.152	36.19	23.20	
	315	-79.4	312.8	1.424	36.05	23.05	
2287.5	0	78.2	Ref.	1.874	35.70	22.71	I_{5V} = 76
	45	47.8	30.4	1.909	35.32	22.33	
	90	-6.0	84.2	1.076	35.62	22.63	I_{12V} = 40
	135	-48.0	126.2	1.318	35.69	22.70	
	180	-100.7	178.9	1.500	35.91	22.92	I_{22V} = 840
	225	-134.5	212.7	1.565	35.72	22.73	
	270	168.0	270.2	1.201	35.92	22.93	
	315	129.6	308.6	1.535	35.87	22.88	

*Current measured at 0° phase setting only.

**Only 0° setting is measured on center modules (P/N SK446962-1)

SIZE	CODE IDENT NO	DRAWING NO
A	96214	SKD0302
SCALE	REV	SHEET 3

TI-7015C

TABLE I. SPACS II MODULE RECORDED TRANSMITTER DATA (CONTINUED)

INPUT POWER LEVEL = +14 DBM

FREQUENCY MHZ	COMMANDED PHASE SETTING DEGREES	MEASURED ** PHASE SETTING DEGREES	$\Delta\phi$	INPUT VSWR	POWER OUTPUT DBM	GAIN DB	POWER SUPPLY* CURRENTS MA
2217.5	0	55.4	Ref.	1.614	34.53	20.79	I_{5V} = 76
	45	50.7	34.7	1.310	34.82	20.78	
	90	-5.0	90.4	1.529	35.00	20.97	I_{12V} = 40
	135	-34.9	120.3	1.646	35.22	21.19	
	180	-104.4	189.8	1.476	35.08	21.07	I_{22V} = 970
	225	-139.0	224.4	1.255	35.30	21.26	
	270	169.7	275.7	1.340	35.42	21.37	
	315	138.0	307.4	1.273	35.17	21.14	
2257.5	0	-125.9	Ref.	1.574	35.99	21.96	I_{5V} = 76
	45	-167.8	41.9	1.511	35.87	21.85	
	90	147.1	87.0	1.089	35.92	21.89	I_{12V} = 41
	135	103.5	130.6	1.322	36.30	22.28	
	180	53.2	180.9	1.046	36.55	22.52	I_{22V} = 960
	225	8.9	225.2	1.176	36.66	22.63	
	270	-36.7	270.8	1.168	36.39	22.36	
	315	-80.2	314.3	1.395	36.12	22.09	
2287.5	0	77.2	Ref.	1.637	36.0	22.03	I_{5V} = 76
	45	45.7	31.5	1.672	35.72	21.75	
	90	-9.9	87.1	1.186	35.81	21.85	I_{12V} = 40
	135	-49.8	127.0	1.263	36.03	22.06	
	180	-103.2	180.4	1.340	36.28	22.32	I_{22V} = 900
	225	-134.6	211.8	1.400	36.09	22.12	
	270	172.3	264.9	1.202	36.09	22.13	
	315	125.1	309.1	1.281	36.16	22.20	

*Current measured at 0° phase setting only.

**Only 0° setting is measured on center modules (P/N SK 446962-1)

SIZE	CODE IDENT NO	DRAWING NO
A	96214	SKD0302
SCALE	REV	SHEET 4

TI-7915C

TABLE II. SPACS II MODULE RECORDED RECEIVER PHASE AND GAIN DATA
(ROOM TEMPERATURE ONLY)

INPUT POWER LEVEL = -40 DBM

FREQUENCY MHZ	COMMANDED PHASE SETTING DEGREES	MEASURED ** PHASE SETTING DEGREES	$\Delta\phi$	INPUT VSWR	GAIN DB	TIME DELAY NSEC	POWER SUPPLY* CURRENTS MA
2030.9	0	-60.0	Ref.	2.383	35.18	14.8	I_{5V} = 75
	45	-102.1	42.1	2.506	35.16	14.9	
	90	-147.8	87.8	2.514	34.30	15.0	I_{12V} = 40
	135	175.2	124.8	2.225	33.50	14.77	
	180	111.9	188.1	2.212	34.61	14.28	
	225	73.5	226.5	2.047	34.57	14.91	
	270	26.7	273.3	2.121	34.53	14.88	
	315	-12.1	312.1	1.979	34.39	14.80	
2041.9	0	-118.9	Ref.	2.033	34.49	13.67	I_{5V} = 75
	45	-161.1	42.2	2.206	34.32	13.84	
	90	152.7	88.4	2.332	33.77	13.10	I_{12V} = 40
	135	116.7	124.4	2.366	33.85	13.67	
	180	55.4	185.7	2.148	34.22	13.49	
	225	14.5	226.6	2.157	34.52	13.69	
	270	-32.3	273.4	2.169	34.55	13.38	
	315	-70.8	311.9	2.131	34.68	13.88	
2052.9	0	-173.0	Ref.	2.070	33.26	12.20	I_{5V} = 75
	45	144.1	42.9	2.267	33.61	11.91	
	90	100.8	86.2	2.471	33.40	12.08	I_{12V} = 40
	135	62.5	124.5	2.827	33.54	13.24	
	180	1.9	185.1	2.43	33.66	11.91	
	225	-39.8	226.8	2.51	34.28	12.28	
	270	-85.3	272.3	2.51	34.00	12.13	
	315	-125.7	312.7	2.58	34.08	13.01	

*Current measured at 0° phase setting only.
**Only 0° setting is measured on center modules (P/N SK446962-1)

SIZE	CODE IDENT NO	DRAWING NO
A	96214	SKD0302
SCALE	REV	SHEET 5

TI-7915C

TABLE II. SPACS II MODULE RECORDED RECEIVER PHASE AND GAIN DATA (CONTINUED)

INPUT POWER LEVEL = -40 DBM

FREQUENCY MHZ	COMMANDED PHASE SETTING DEGREES	MEASURED ** PHASE SETTING DEGREES	$\Delta\phi$	INPUT VSWR	GAIN DB	TIME DELAY NSEC	POWER SUPPLY* CURRENTS MA
2074.15	0	93.1	Ref.	1.667	33.03	12.12	I_{5V} = 75
	45	48.9	44.2	1.681	33.40	12.87	
	90	2.9	90.2	1.805	33.31	12.77	I_{12V} = 40
	135	-40.7	133.8	2.097	33.36	12.56	
	180	-91.5	184.6	1.920	33.59	12.21	
	225	-136.6	229.7	2.039	33.57	12.78	
	270	177.3	275.8	1.999	33.17	12.50	
	315	132.8	320.3	2.059	33.24	11.92	
2095.4	0	-4.2	Ref.	2.470	33.55	13.44	I_{5V} = 75
	45	-51.6	47.4	2.185	33.75	13.24	
	90	-96.8	92.6	2.042	33.34	13.35	I_{12V} = 40
	135	-138.4	134.2	2.108	32.51	13.096	
	180	170.5	185.3	2.360	33.35	12.970	
	225	125.1	230.7	2.334	33.17	12.26	
	270	81.3	274.5	2.312	33.14	12.91	
	315	38.5	317.3	2.361	32.69	12.55	
2106.4	0	-57.4	Ref.	2.324	34.54	16.434	I_{5V} = 75
	45	-104.0	46.6	1.899	34.17	16.144	
	90	-149.7	92.3	1.722	33.40	15.98	I_{12V} = 40
	135	169.8	132.8	1.722	32.88	15.10	
	180	119.1	183.5	2.023	34.03	15.37	
	225	76.6	226.0	1.969	33.56	15.41	
	270	30.2	272.4	1.965	33.51	15.33	
	315	-11.2	313.8	2.008	33.41	15.0	

*Current measured at 0° phase setting only.

**Only 0° setting is measured on center modules (P/N SK446962-1)

SIZE	CODE IDENT NO	DRAWING NO
A	96214	SKDD302
SCALE	REV	SHEET 6

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TABLE II. SPACS II MODULE RECORDED RECEIVER PHASE AND GAIN DATA (CONTINUED)

INPUT POWER LEVEL = -40 DBM

FREQUENCY MHZ	COMMANDED PHASE SETTING DEGREES	MEASURED** PHASE SETTING DEGREES	$\Delta\phi$	INPUT VSWR	GAIN DB	TIME DELAY NSEC	POWER SUPPLY* CURRENT MA
2117.4	0	-122.5	Ref.	2.239	34.45	16.42	I_{5V} = 75
	45	-168.0	45.5	1.990	33.81	15.74	
	90	147.0	90.5	1.770	33.53	15.25	I_{12V} = 40
	135	110.0	127.5	1.558	33.63	16.21	
	180	58.3	179.2	1.776	34.12	15.83	
	225	15.6	221.9	1.703	33.99	15.71	
	270	-30.5	268.0	1.713	34.11	15.62	
	315	-70.6	308.1	1.66	34.28	16.28	

*Current measured at 0° phase setting only.

**Only 0° setting is measured on center modules (P/N SK446962-1)

SIZE	CODE IDENT NO	DRAWING NO
A	96214	SKDD302
SCALE	REV	SHEET 7

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TABLE III. SPACS II MODULE ADDITIONAL RECEIVER TEST DATA (NOISE FIGURE AND COMPRESSION AT ROOM TEMPERATURE ONLY)

FREQUENCY MHZ	RECEIVER NOISE FIGURE DB	RECEIVER NOISE TEMPERATURE °K	RECEIVER OUTPUT 1 DB COMPRESSION POINT DBM	ANTENNA PORT INPUT POWER LEVEL DBM	RECEIVER GAIN DB
2030.9	4.5	527.3	+8.7	-25.2	35.9
2041.9	4.6	546.4	+9.2	-24.0	33.2
2052.9	4.6	546.4	+9.6	-22.1	32.5
2074.15	4.7	565.9	+10.0	-21.4	31.4
2095.4	4.1	455.4	+10.2	-21.7	31.9
2106.4	4.1	455.4	+10.3	-22.2	32.5
2117.4	4.2	472.8	+10.5	-23.1	33.6

TABLE IV. SPACS II MODULE DUPLEX EVALUATION TESTS FOR RECEIVER COMPRESSION

RECEIVE LEVEL (DBM)		TRANSMIT LEVEL (DBM)		FREQUENCY (MHZ)	LOAD VSWR
AT ANTENNA	AT RCV OUTPUT	AT ANTENNA	AT RCV OUTPUT	XMIT/RCV	
-40	-5.5	--	—	OFF/2041.9	1.6:1
-40	-7.5	> +35	+9.0	2217.5/2041.9	1.6:1
-40	-5.0	--	—	OFF/2106.4	1.6:1
-40	-5.5	> +35	-4.5	2287.5/2106.4	1.6:1

SIZE	CODE IDENT NO	DRAWING NO
A	96214	SKDD302
SCALE	REV	SHEET 8

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TABLE IV. DUPLEX OPERATION CONTINUED, INTERMODULATION PRODUCT EVALUATION (ROOM TEMPERATURE) SUMMARY

FREQUENCY (MHZ) XMIT/RCVR	LOAD VSWR	INTERMODULATION FREQUENCY/DBC F1/IM1	F2/IM2	F3/IM3	F4/IM4
2217.5/2041.9	1.05:1	>30	>40	>40	—
2217.5/2041.9	1.6:1	>30	2390 MHz / >20	>40	—
2287.5/2106.4	1.05:1	>40	>40	>40	—
2287.5/2106.4	1.6:1	>30	>40	>40	—

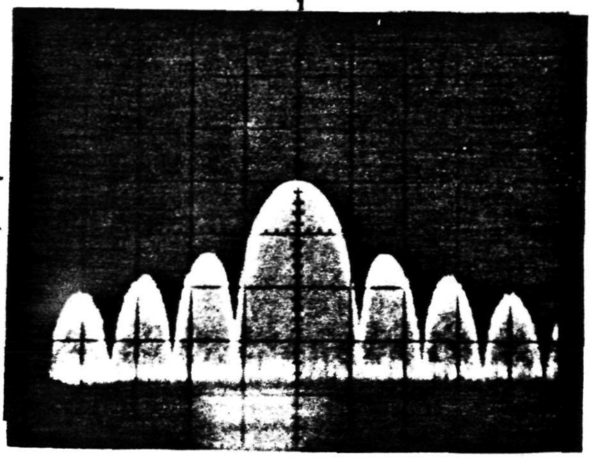
SIZE	CODE IDENT NO	DRAWING NO
A	96214	SKDD302
SCALE	REV	SHEET 9 1

TI-7915C

TABLE V. SPACS II MODULE - DUPLEX OPERATION, PULSE MODULATION TESTS, PHOTOGRAPHS

2041.9 MHZ

10dB/div



4.6 MHZ

(A)

TRANSMITTER OFF

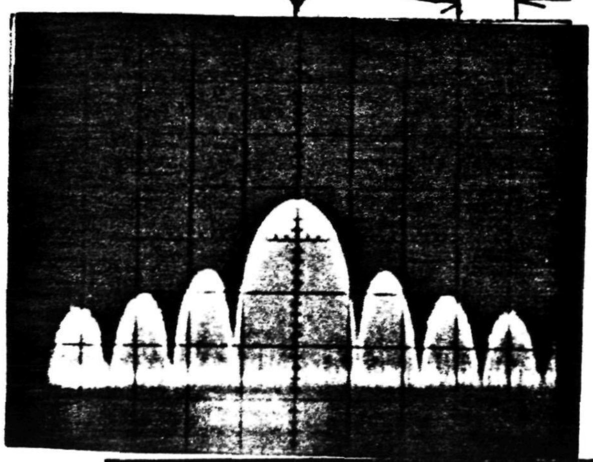
RECEIVE CARRIER
f_R=2041.9 MHZ

INPUT = -40 DBM

OUTPUT = -5.5DBM

2041.9 MHZ

1 MHZ/Div



(B)

TRANSMITTER ON
f_T=2217.5 MHZ

RECEIVE CARRIER
f_R=2041.9 MHZ

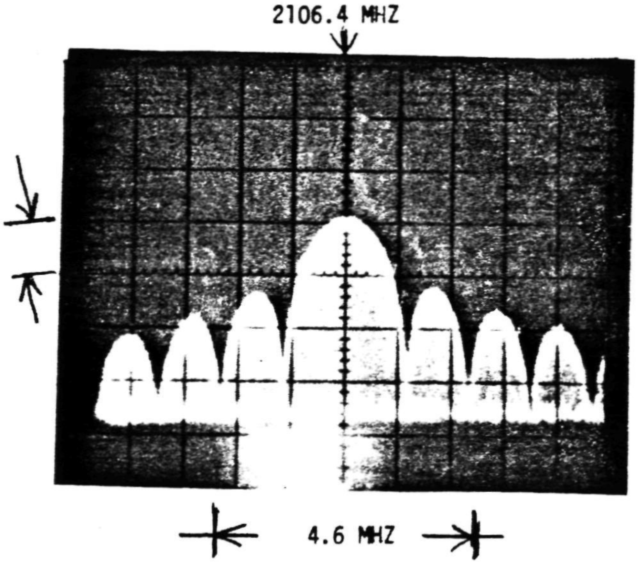
INPUT = -40 DBM

OUTPUT = -7.5 DBM

SIZE	CODE IDENT NO	DRAWING NO
A	96214	SKDD302
SCALE	REV	SHEET 10 / 1

TI-7915C

TABLE V. PULSED MODULATION PHOTOGRAPHS CONTINUED



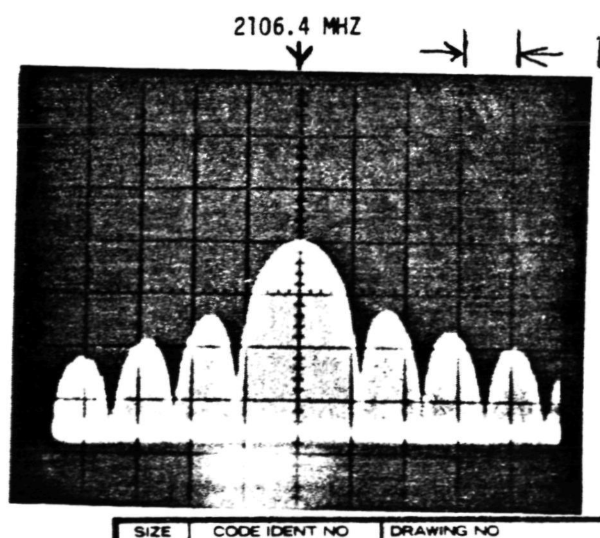
(C)

TRANSMITTER OFF

RECEIVE CARRIER
f_R=2106.4 MHZ

INPUT = -40 DBM

OUTPUT = 5.0 DBM



(D)

TRANSMITTER ON
f_T=2287.5 MHZ

RECEIVE CARRIER
f_R=2106.4 MHZ

INPUT = -40 DBM

OUTPUT = 5.5 DBM

SIZE	CODE IDENT NO	DRAWING NO
A	96214	SKD0302
SCALE	REV	SHEET 11

TABLE VI. SPACS II MODULE SUMMARY OF L-BAND RECEIVER SECTION OF MODULE

FREQUENCY MHZ	ANTENNA CONNECTOR POWER LEVEL DBM	L-BAND INSERTION LOSS DB	CORRESPONDING NOISE TEMPERATURE K°
1600	N.A.	N. A.	N. A.
1775.5			
1803.65			
1831.8			
2000			

SIZE	CODE IDENT NO	DRAWING NO
A	96214	SKDD302
SCALE	REV	SHEET 12

TI-7915C

A

APPLICATION		REVISIONS			
NEXT ASSY	USED ON	LTR	DESCRIPTION	DATE	APPROVED
SK784010-1	1207				
SK446962-1	1207				

SPACS II - TRANSMIT/RECEIVE MICROELECTRONICS MODULE

MEASUREMENT DATA SHEETS FOR OUTER MODULES

(P/N SK784010-1) AND FOR CENTER MODULES

(P/N SK446962-1)

REF: NASA/JSC HOUSTON, TEXAS

CONTRACT: NAS9-14485

A/T FINAL DATA: 8-15-75

MODULE PART NUMBER SK784010-1
(RECORD)

MODULE SERIAL NUMBER 003
(RECORD)

R. allison

REV	
SHEET	
REV STATUS OF SHEETS	REV
	SHEET

UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES TOLERANCES ANGLES ±1° 3 PLACE DECIMAL±.010 2 PLACE DECIMAL±.02	DWN D. Harbison DATE 5-9-75	TEXAS INSTRUMENTS INCORPORATED Equipment Group Dallas, Texas		
	CHK			
IDENTIFYING NUMBERS SHOWN IN PARENTHESES FOR REFERENCE ONLY	ENGR D. Pezer 5-15-75	SPACS II-TRANSMIT/RECEIVE MICROELECTRONICS MODULE MEASUREMENT DATA SHEETS		
	QA			
INTERPRET DWG IN ACCORDANCE WITH MIL-STD-100	APVD			
	CONTR NO	SIZE A	CODE IDENT NO 96214	DRAWING NO SKDD302
	DESIGN ACTIVITY RELEASE			
		SCALE		SHEET 1 OF 12

TI-0923-C PI

TABLE I. SPACS II MODULE RECORDED TRANSMITTER DATA
(ROOM TEMPERATURE ONLY)

INPUT POWER LEVEL = +12 DBM

FREQUENCY MHZ	COMMANDED PHASE SETTING DEGREES	MEASURED ** PHASE SETTING DEGREES	Δφ	INPUT VSWR	POWER OUTPUT DBM	GAIN DB	POWER SUPPLY* CURRENTS MA
2217.5	0	73.8	REF	1.494	35.63	23.61	I_{5V} = 101
	45	18.8	[illegible]	1.897	35.52	23.5	
	90	-24.0	97.8	1.561	35.65	23.63	I_{12V} = 44
	135	-84.3	158.1	1.325	35.46	23.44	
	180	-125.6	[illegible]	1.392	35.42	23.40	
	225	-172.5	246.3	1.708	35.57	23.55	I_{22V} = 1120
	270	144.1	292.7	1.698	35.62	23.60	
	315	99.1	334.7	1.373	35.49	23.47	
2257.5	0	-115.1	REF	2.266	35.65	23.70	I_{5V} = 101
	45	-152.5	37.4	1.854	35.94	23.90	
	90	151.1	[illegible]	1.790	35.98	24.01	I_{12V} = 44
	135	105.5	139.4	1.414	35.63	23.65	
	180	52.9	192.0	1.787	35.49	23.51	
	225	16.4	228.5	1.861	35.93	23.95	I_{22V} = 760
	270	-35.9	280.8	2.344	35.90	23.93	
	315	-82.1	327.0	1.708	35.46	23.48	
2287.5	0	138.2	REF	2.563	34.75	22.75	I_{5V} = 101
	45	76.5	53.7	1.437	35.17	23.17	
	90	25.8	104.4	1.934	34.80	22.80	I_{12V} = 44
	135	-20.7	150.9	1.600	34.90	22.90	
	180	-65.7	195.9	1.970	34.70	22.70	I_{22V} = 610
	225	-108.2	235.4	1.756	35.15	23.15	
	270	-156.8	287.0	2.103	34.82	22.82	
	315	155.9	334.3	2.252	34.67	22.68	

*Current measured at 0° phase setting only.

**Only 0° setting is measured on center modules (P/N SK446962-1)

SIZE	CODE IDENT NO	DRAWING NO
A	96214	SKKDD302
SCALE	REV	SHEET 2 3

FI-7915C

TABLE I. SPACS II MODULE RECORDED TRANSMITTER DATA
(CONTINUED

INPUT POWER LEVEL = +13 DBM

FREQUENCY MHZ	COMMANDED PHASE SETTING DEGREES	MEASURED ** PHASE SETTING DEGREES	$\Delta\phi$	INPUT VSWR	POWER OUTPUT DBM	GAIN DB	POWER SUPPLY* CURRENTS MA
2217.5	0	72.6	REF	1.341	35.58	22.57	I_{5V} = 101
	45	17.4	55.2	1.753	35.47	22.47	
	90	-24.8	97.4	1.486	35.58	22.57	I_{12V} = 44
	135	-85.3	157.9	1.262	35.41	22.40	
	180	-125.6	198.2	1.221	35.35	22.34	I_{22V} = 1130
	225	-173.6	246.2	1.566	35.53	22.52	
	270	145.2	287.4	1.507	35.57	22.56	
	315	99.9	332.7	1.257	35.45	22.44	
2257.5	0	-115.8	REF	1.942	35.66	22.66	I_{5V} = 101
	45	-159.0	43.2	1.558	35.80	22.80	
	90	149.9	94.3	1.549	35.85	22.85	I_{12V} = 44
	135	101.7	142.5	1.219	35.52	22.52	
	180	52.7	191.5	1.548	35.45	22.45	I_{22V} = 1020
	225	11.7	232.5	1.592	35.82	22.83	
	270	-36.7	280.9	1.958	35.78	22.78	
	315	-82.4	326.6	1.517	35.38	22.39	
2287.5	0	125.9	REF	2.186	35.03	22.04	I_{5V} = 101
	45	73.7	52.2	1.328	35.16	22.17	
	90	23.9	102.0	1.790	34.96	21.97	I_{12V} = 44
	135	-22.1	148.0	1.480	34.98	21.99	
	180	-70.0	195.9	1.776	34.95	21.96	I_{22V} = 710
	225	-112.7	238.6	1.616	35.21	22.22	
	270	-158.2	284.1	1.913	34.97	21.98	
	315	154.8	331.1	2.059	34.85	21.86	

*Current measured at 0° phase setting only.

**Only 0° setting is measured on center modules (P/N SK446962-1)

SIZE	CODE IDENT NO	DRAWING NO
A	96214	SKDD302
SCALE	REV	SHEET 3 3

TI-7915C

TABLE I. SPACS II MODULE RECORDED TRANSMITTER DATA
(CONTINUED)

INPUT POWER LEVEL = +14 DBM

FREQUENCY MHZ	COMMANDED PHASE SETTING DEGREES	MEASURED ** PHASE SETTING DEGREES	$\Delta\phi$	INPUT VSWR	POWER OUTPUT DBM	GAIN DB	POWER SUPPLY* CURRENTS MA
2217.5	0	72.7	REF	1.183	[illegible]	21.57	I_{5V} = 101
	45	17.8	55.9	1.614	35.49	21.48	
	90	-23.4	[illegible]	1.416	[illegible]	21.58	I_{12V} = 44
	135	-83.9	157.6	1.212	35.43	21.41	
	180	-125.2	198.4	1.046	35.26	[illegible]	I_{22V} = 1150
	225	-172.2	245.9	1.405	35.53	21.52	
	270	147.2	285.5	1.350	35.58	21.56	
	315	102.0	331.7	1.192	35.65	21.44	
2257.5	0	-115.4	REF	1.748	35.65	21.65	I_{5V} = 101
	45	-161.1	45.7	1.241	35.50	21.79	
	90	150.2	94.4	1.420	35.78	21.77	I_{12V} = 44
	135	100.9	143.7	1.097	35.5	21.49	
	180	53.2	191.4	1.521	35.46	21.46	I_{22V} = 1040
	225	8.9	235.7	1.411	35.75	21.74	
	270	-36.5	281.1	1.737	35.70	21.69	
	315	-81.8	326.4	1.436	35.37	21.26	
2287.5	0	124.2	REF	1.949	35.19	21.17	I_{5V} = 101
	45	71.6	52.6	1.311	35.21	21.19	
	90	23.6	100.6	1.744	35.08	21.06	I_{12V} = 44
	135	-23.1	147.3	1.456	35.10	21.08	
	180	-70.6	194.8	1.708	35.10	21.05	I_{22V} = 810
	225	-114.0	238.2	1.610	35.25	21.23	
	270	-158.7	282.9	1.828	35.08	21.06	
	315	154.7	329.5	1.962	34.94	20.92	

*Current measured at 0° phase setting only.

** Only 0° setting is measured on center modules (P/N SK 446962-1)

SIZE	CODE IDENT NO	DRAWING NO
A	96214	SKD0302

SCALE REV SHEET 4 3

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TABLE II. SPACS II MODULE RECORDED RECEIVER PHASE AND GAIN DATA (ROOM TEMPERATURE ONLY)

INPUT POWER LEVEL = -40 DBM

FREQUENCY MHZ	COMMANDED PHASE SETTING DEGREES	MEASURED ** PHASE SETTING DEGREES		INPUT VSWR	GAIN DB	TIME DELAY NSEC	POWER SUPPLY* CURRENTS MA
2030.9	0	-75.8	REF	1.139	32.62	18.511	I_{5V} = 99
	45	-113.0	37.2	1.234	31.71	18.659	
	90	-151.6	75.8	1.351	31.40	18.211	I_{12V} = 45
	135	153.4	120.8	1.356	31.77	17.537	
	180	110.1	174.1	1.354	31.85	17.728	
	225	71.3	212.9	1.321	31.43	18.956	
	270	31.9	252.3	1.314	31.28	19.592	
	315	-12.8	297.0	1.255	32.05	20.152	
2041.9	0	-149.1	REF	1.258	33.05	15.793	I_{5V} = 99
	45	173.1	37.8	1.257	32.21	15.248	
	90	136.3	74.6	1.129	32.42	15.304	I_{12V} = 45
	135	84.0	126.9	1.045	33.09	15.927	
	180	39.9	171.0	1.107	33.20	16.950	
	225	-3.7	214.6	1.140	32.69	16.470	
	270	-45.7	256.6	1.189	32.95	16.398	
	315	-92.6	303.5	1.297	33.68	16.808	
2052.9	0	148.4	REF	2.241	32.82	12.891	I_{5V} = 99
	45	112.7	35.7	2.361	32.14	13.205	
	90	75.7	72.7	2.193	32.65	14.513	I_{12V} = 45
	135	20.9	127.5	1.929	33.15	14.303	
	180	-27.2	175.6	1.746	33.66	14.266	
	225	-69.0	217.4	1.839	33.00	14.163	
	270	-110.6	259.0	1.805	32.99	14.537	
	315	-159.1	307.5	2.046	33.17	13.655	

*Current measured at 0° phase setting only.
**Only 0° setting is measured on center modules (P/N SK446962-1)

SIZE	CODE IDENT NO	DRAWING NO
A	96214	SKDD302
SCALE	REV	SHEET 5 3

TI 7915C

ORIGINAL PAGE IS OF POOR QUALITY

TABLE II. SPACS II MODULE RECORDED RECEIVER PHASE AND GAIN DATA (CONTINUED)

INPUT POWER LEVEL = -40 DBM

FREQUENCY MHZ	COMMANDED PHASE SETTING DEGREES	MEASURED ** PHASE SETTING DEGREES		INPUT VSWR	GAIN DB	TIME DELAY NSEC	POWER SUPPLY* CURRENTS MA
2074.15	0	[illegible]	REF	2.072	31.52	[illegible]	I_{5V} = 99
	45	107	38.2	2.614	31.25	12.99[illegible]	
	90	[illegible]	81.6	[illegible]	[illegible]	12.[illegible]	I_{12V} = 45
	135	-86.7	133.6	2.791	32.21	13.22[illegible]	
	180	[illegible]	152.3	2.427	[illegible]	12.422	
	225	-172.2	222.2	[illegible]	31.34	11.964	
	270	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	
	315	101.1	207.8	[illegible]	[illegible]	[illegible]	
2095.4	0	-58.2	REF	[illegible]	[illegible]	12.[illegible]	I_{5V} = 99
	45	-98.0	39.8	1.823	31.91	12.[illegible]	
	90	-143.9	85.7	1.973	[illegible]	[illegible]	I_{12V} = 45
	135	172.7	129.1	1.612	[illegible]	12.265	
	180	127.3	185.5	[illegible]	31.69	12.06[illegible]	
	225	88.0	213.8	1.410	31.75	[illegible]	
	270	42.8	[illegible]	1.390	31.60	[illegible]	
	315	-1.2	302.0	[illegible]	[illegible]	[illegible]	
2106.4	0	-112.3	REF	1.236	32.09	[illegible]	I_{5V} = 99
	45	-151.4	38.1	1.577	31.62	14.259	
	90	[illegible]	80.2	1.829	31.51	14.196	I_{12V} = 45
	135	120.1	[illegible]	1.595	31.63	14.318	
	180	77.1	169.6	1.553	31.35	13.791	
	225	36.6	210.1	1.441	[illegible]	14.114	
	270	-7.3	254.0	1.421	31.81	14.801	
	315	-55.2	301.9	1.204	[illegible]	[illegible]	

*Current measured at 0° phase setting only.

**Only 0° setting is measured on center modules (P/N SK446962-1)

SIZE	CODE IDENT NO	DRAWING NO
A	96214	SKDD302
SCALE	REV	SHEET 6 3

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TABLE II. SPACS II MODULE RECORDED RECEIVER PHASE AND GAIN DATA (CONTINUED)

INPUT POWER LEVEL = -40 DBM

FREQUENCY MHZ	COMMANDED PHASE SETTING DEGREES	MEASURED** PHASE SETTING DEGREES		INPUT VSWR	GAIN DB	TIME DELAY NSEC	POWER SUPPLY* CURRENT MA
2117.4	0	-170.7	REF	1.414	31.96	15.875	I_{5V} = 99
	45	152.4	36.9	1.375	31.36	16.059	
	90	110.3	79.0	1.227	31.54	16.037	I_{12V} = 45
	135	67.4	121.9	1.069	32.22	15.836	
	180	22.5	193.2	1.111	32.25	16.727	
	225	-19.3	208.6	1.116	32.01	16.852	
	270	-65.9	255.2	1.116	32.29	16.432	
	315	-115.6	304.9	1.339	32.90	16.068	

*Current measured at 0° phase setting only.

**Only 0° setting is measured on center modules (P/N SK446962-1)

SIZE	CODE IDENT NO	DRAWING NO
A	96214	SKDD302
SCALE	REV	SHEET 7 3

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C-2

TABLE III. SPACS II MODULE ADDITIONAL RECEIVER TEST DATA
(NOISE FIGURE AND COMPRESSION AT
ROOM TEMPERATURE ONLY)

FREQUENCY MHZ	RECEIVER NOISE FIGURE DB	RECEIVER NOISE TEMPERATURE °K	RECEIVER OUTPUT 1 DB COMPRESSION POINT DBM	ANTENNA PORT INPUT POWER LEVEL DBM	RECEIVE GAIN DB
2030.9	6.7	1066.4	+8.58	-20.7	29.3
2041.9	6.1	891.4	+7.52	-21.5	29.0
2052.9	6.0	864.5	+4.28	-23.52	27.8
2074.15	6.7	1066.4	+0.13	-23.48	23.61
2095.4	5.7	787.5	-0.45	[illegible]	20.45
2106.4	5.3	692.7	+1.1	-20.06	21.16
2117.4	5.2	670.3	[illegible]	-17.95	17.62

TABLE IV. SPACS II MODULE DUPLEX EVALUATION
TESTS FOR RECEIVER COMPRESSION

RECEIVE LEVEL (DBM)		TRANSMIT LEVEL (DBM)		FREQUENCY (MHZ)	LOAD VSWR
AT ANTENNA	AT RCV OUTPUT	AT ANTENNA	AT RCV OUTPUT	XMIT/RCV	
-40	-7.0	--	—	OFF/2041.9	1.6:1
-40	-10.0	> +35	+10.0	2217.5/2041.9	1.6:1
-40	-8.0	--	—	OFF/2106.4	1.6:1
-40	-9.0	> +35	-4.0	2287.5/2106.4	1.6:1

SIZE	CODE IDENT NO	DRAWING NO
A	96214	SKDD302
SCALE	REV	SHEET 8

TABLE IV. DUPLEX OPERATION CONTINUED, INTERMODULATION PRODUCT EVALUATION (ROOM TEMPERATURE) SUMMARY

		INTERMODULATION FREQUENCY/DBC			
FREQUENCY (MHZ)	LOAD VSWR	F1/IM1	F2/IM2	F3/IM3	F4/IM4
XMIT/RCVR					
2217.5/2041.9	1.05:1	>30	>40	>40	—
2217.5/2041.9	1.6:1	>30	2390 MHz >20	>40	—
2287.5/2106.4	1.05:1	>40	>40	>40	—
2287.5/2106.4	1.6:1	>30	>40	>40	—

SIZE	CODE IDENT NO	DRAWING NO
A	96214	SKDD302

SCALE | REV | SHEET 9 3

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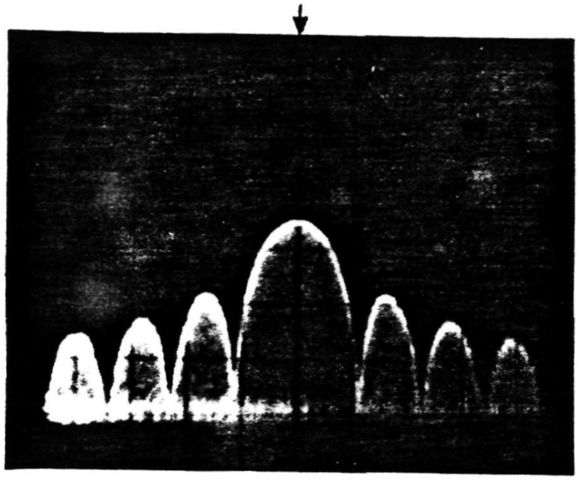
TABLE V. SPACS II MODULE - DUPLEX OPERATION, PULSE MODULATION TESTS, PHOTOGRAPHS

2041.9 MHZ

10 dB/DIV



4.6 MHZ

(A)

TRANSMITTER OFF

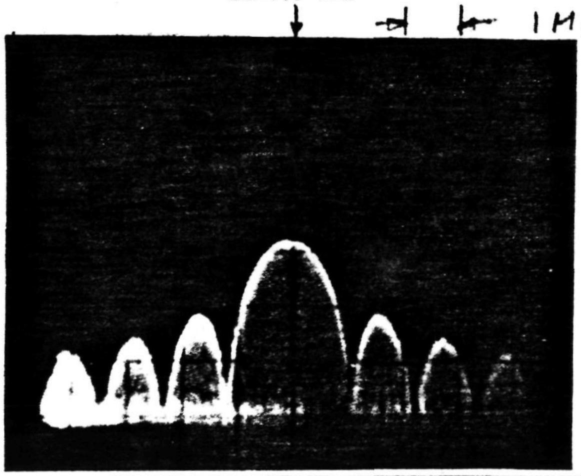
RECEIVE CARRIER
f_R=2041.9 MHZ

INPUT = -40 DBM

OUTPUT = -7 DBM

2041.9 MHZ

1 MHz/DIV



(B)

TRANSMITTER ON
f_T=2217.5 MHZ

RECEIVE CARRIER
f_R=2041.9 MHZ

INPUT = -40 DBM

OUTPUT = -10 DBM

SIZE	CODE IDENT NO	DRAWING NO
A	96214	SKDD302

SCALE	REV	SHEET 10	3

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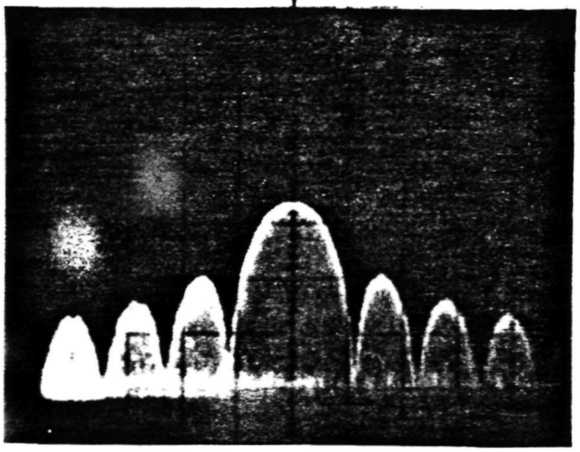
TABLE V. PULSED MODULATION PHOTOGRAPHS CONTINUED

2106.4 MHZ

10dB/DIV



(C)

TRANSMITTER OFF

RECEIVE CARRIER
f_R=2106.4 MHZ

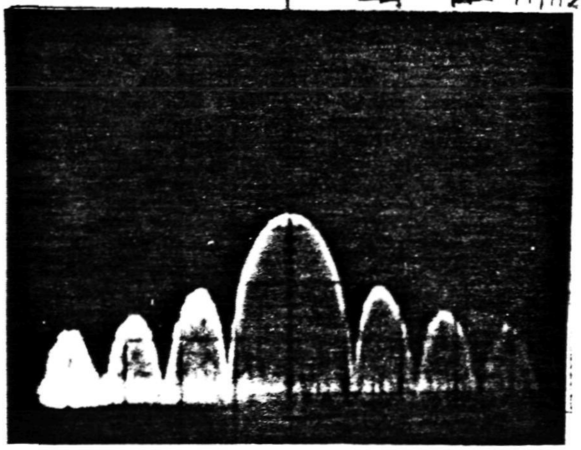
INPUT = -40 DBM

OUTPUT = -8 DBM

4.6 MHZ

2106.4 MHZ

1MHz/DIV



(D)

TRANSMITTER ON
f_T=2287.5 MHZ

RECEIVE CARRIER
f_R=2106.4 MHZ

INPUT = -40 DBM

OUTPUT = -9 DBM

SIZE	CODE IDENT NO	DRAWING NO	
A	96214	SKDD302	B-23
SCALE	REV	SHEET 11	3

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TABLE VI. SPACS II MODULE SUMMARY OF L-BAND RECEIVER SECTION OF MODULE

FREQUENCY MHZ	ANTENNA CONNECTOR POWER LEVEL DBM	L-BAND INSERTION LOSS DB	CORRESPONDING NOISE TEMPERATURE K°
1600	N.A.	N.A.	N.A.
1775.5			
1803.65			
1831.8			
2000			

SIZE	CODE IDENT NO	DRAWING NO	
A	96214	SKDD302	B-24
SCALE	REV	SHEET 12	3

APPLICATION	
NEXT ASSY	USED ON
SK784010-1	1207
SK446962-1	1207

REVISIONS			
LTR	DESCRIPTION	DATE	APPROVED

SPACS II - TRANSMIT/RECEIVE MICROELECTRONICS MODULE

MEASUREMENT DATA SHEETS FOR OUTER MODULES

(P/N SK784010-1) AND FOR CENTER MODULES

(P/N SK446962-1)

REF: NASA/JSC HOUSTON, TEXAS

CONTRACT: NAS9-14485

A/T Final Data: 8-1-75

MODULE PART NUMBER SK784010-1 (RECORD)

MODULE SERIAL NUMBER 004 (RECORD)

DRD

REV																												
SHEET																												

REV STATUS OF SHEETS	REV	
	SHEET	

UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES TOLERANCES ANGLES ±1° 3 PLACE DECIMAL ±.010 2 PLACE DECIMAL ±.02

IDENTIFYING NUMBERS SHOWN IN PARENTHESES FOR REFERENCE ONLY

INTERPRET DWG IN ACCORDANCE WITH MIL-STD-100

DWN D. Harkison DATE 5-9-75

CHK

ENGR D. Pezor 5-15-75

QA

APVD

CONTR NO

DESIGN ACTIVITY RELEASE

TEXAS INSTRUMENTS INCORPORATED Equipment Group Dallas, Texas

SPACS II-TRANSMIT/RECEIVE MICROELECTRONICS MODULE MEASUREMENT DATA SHEETS

SIZE	CODE IDENT NO	DRAWING NO
A	96214	SKDD302
SCALE		SHEET 1 OF 12

TI-0023-C P1

TABLE I. SPACS II MODULE RECORDED TRANSMITTER DATA
(ROOM TEMPERATURE ONLY)

INPUT POWER LEVEL = +12 DBM

FREQUENCY MHZ	COMMANDED PHASE SETTING DEGREES	MEASURED ** PHASE SETTING DEGREES	Δφ	INPUT VSWR	POWER OUTPUT DBM	GAIN DB	POWER SUPPLY* CURRENTS MA
2217.5	0	82.7	Ref.	1.235	35.22	23.21	I_{5V} = 95
	45	23.7	59.0	1.815	35.07	23.06	
	90	-8.5	91.2	1.550	34.58	22.58	I_{12V} = 44
	135	-80.0	162.7	1.405	34.64	22.64	
	180	-110.8	193.5	1.178	33.17	21.16	
	225	-170.5	253.2	1.587	34.93	22.9[illegible]	I_{22V} = 950
	270	160.1	282.6	1.682	34.71	22.70	
	315	109.2	333.5	1.476	34.71	22.70	
2257.5	0	-132.2	Ref.	1.914	35.30	23.33	I_{5V} = 95
	45	-156.8	24.6	2.363	34.97	23.00	
	90	145.1	82.7	1.669	35.15	23.16	I_{12V} = 44
	135	97.3	130.5	1.684	35.32	23.33	
	180	48.3	179.5	1.268	35.13	23.14	
	225	9.2	218.6	1.945	34.99	22.98	I_{22V} = 810
	270	-39.4	267.2	1.700	35.05	23.06	
	315	-86.3	314.1	1.421	35.03	23.04	
2287.5	0	101.6	Ref.	2.316	33.57	21.57	I_{5V} = 95
	45	54.0	47.6	1.525	34.44	22.44	
	90	6.6	95.0	1.323	34.13	22.12	I_{12V} = 44
	135	-44.7	146.3	1.418	34.38	22.37	
	180	-90.3	191.9	1.609	34.15	22.14	I_{22V} = 590
	225	-130.8	232.4	1.479	34.56	22.55	
	270	-175.4	277.0	1.527	34.04	22.03	
	315	133.7	327.9	1.799	34.17	22.16	

*Current measured at 0° phase setting only.

**Only 0° setting is measured on center modules (P/N SK446962-1)

SIZE	CODE IDENT NO	DRAWING NO
A	96214	SKKDD302

SCALE | REV | SHEET 2

TI-7915C

TABLE I. SPACS II MODULE RECORDED TRANSMITTER DATA (CONTINUED

INPUT POWER LEVEL = +13 DBM

FREQUENCY MHZ	COMMANDED PHASE SETTING DEGREES	MEASURED ** PHASE SETTING DEGREES	$\Delta\phi$	INPUT VSWR	POWER OUTPUT DBM	GAIN DB	POWER SUPPLY* CURRENTS MA
2217.5	0	62.5	Ref.	1.174	35.33	22.32	I_{5V} = 95
	45	10.3	52.2	1.804	35.20	22.19	
	90	-22.1	84.6	1.795	34.80	21.80	I_{12V} = 44
	135	-92.5	155.0	1.432	34.60	21.60	
	180	-126.6	189.1	1.164	34.87	21.87	I_{22V} = 900
	225	179.3	243.2	1.499	34.81	21.82	
	270	146.3	276.2	1.599	34.73	21.73	
	315	97.4	325.1	1.441	34.76	21.76	
2257.5	0	-133.6	Ref.	1.669	35.36	22.35	I_{5V} = 95
	45	-167.8	34.2	2.065	35.32	22.31	
	90	142.0	84.4	1.397	35.15	22.14	I_{12V} = 44
	135	92.1	134.3	1.426	35.28	22.28	
	180	47.2	179.2	1.227	35.32	22.31	I_{22V} = 930
	225	3.0	223.4	1.650	35.04	22.03	
	270	-41.6	268.0	1.446	35.10	22.09	
	315	-88.4	314.8	1.230	35.07	22.06	
2287.5	0	93.5	Ref.	2.122	34.20	21.23	I_{5V} = 95
	45	48.7	44.8	1.317	34.71	21.75	
	90	2.6	90.9	1.258	34.40	21.40	I_{12V} = 44
	135	-47.4	140.9	1.257	34.55	21.55	
	180	-93.0	186.5	1.491	34.60	21.60	I_{22V} = 660
	225	-134.5	228.0	1.304	34.77	21.77	
	270	-179.0	272.5	1.426	34.43	21.44	
	315	131.5	322.0	1.680	34.50	21.51	

*Current measured at 0° phase setting only.

**Only 0° setting is measured on center modules (P/N SK446962-1)

SIZE	CODE IDENT NO	DRAWING NO
A	96214	SKDD302
SCALE	REV	SHEET 3 4

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TABLE I. SPACS II MODULE RECORDED TRANSMITTER DATA
(CONTINUED)

INPUT POWER LEVEL = +14 DBM

FREQUENCY MHZ	COMMANDED PHASE SETTING DEGREES	MEASURED ** PHASE SETTING DEGREES	Δφ	INPUT VSWR	POWER OUTPUT DBM	GAIN DB	POWER SUPPLY* CURRENTS MA
2217.5	0	55.4	Ref.	1.175	35.23	21.21	I_{5V} = 95
	45	1.8	53.6	1.704	35.12	21.10	
	90	-30.6	86.0	1.715	34.76	20.75	I_{12V} = 44
	135	-97.1	152.5	1.473	34.59	20.58	
	180	-133.8	189.2	1.285	34.54	20.5[illegible]	I_{22V} = 790
	225	175.8	239.6	1.366	34.74	20.72	
	270	141.5	273.9	1.528	34.67	[illegible]	
	315	92.9	322.5	1.457	34.73	20.71	
2252.5	0	-133.6	Ref.	1.552	35.40	21.35	I_{5V} = 95
	45	-173.5	39.9	1.730	35.45	21.40	
	90	140.6	85.8	1.194	35.17	21.14	I_{12V} = 44
	135	90.1	136.3	1.231	35.29	21.26	
	180	47.1	179.3	1.329	35.33	21.30	I_{22V} = 765
	225	0.5	225.8	1.384	35.11	21.0[illegible]	
	270	-42.2	268.6	1.312	35.09	21.06	
	315	-89.0	315.4	1.164	35.02	20.99	
2287.5	0	89.4	Ref.	1.887	34.64	20.62	I_{5V} = 95
	45	44.5	44.9	1.142	34.96	20.94	
	90	0.8	88.6	1.280	34.62	20.61	I_{12V} = 44
	135	-48.7	138.1	1.247	34.73	20.72	
	180	-93.8	183.2	1.456	34.57	20.86	I_{22V} = 720
	225	-136.6	226.0	1.237	34.93	20.91	
	270	179.6	269.8	1.427	34.64	20.62	
	315	130.6	318.8	1.654	34.70	20.68	

*Current measured at 0° phase setting only.

** Only 0° setting is measured on center modules (P/N SK 446962-1)

SIZE	CODE IDENT NO	DRAWING NO
A	96214	SKDD302

SCALE	REV	SHEET 4

TI-7915C

TABLE II. SPACS II MODULE RECORDED RECEIVER PHASE AND GAIN DATA
(ROOM TEMPERATURE ONLY)

INPUT POWER LEVEL = -40 DBM

FREQUENCY MHZ	COMMANDED PHASE SETTING DEGREES	MEASURED ** PHASE SETTING DEGREES	$\Delta\phi$	INPUT VSWR	GAIN DB	TIME DELAY NSEC	POWER SUPPLY* CURRENTS MA
2030.9	0	-57.3	Ref.	3.505	29.99	13.034	I_{5V} = 93
	45	-123.9	66.6	3.087	26.34	11.415	
	90	-167.8	110.5	2.577	26.64	11.083	I_{12V} = 44
	135	179.3	123.4	2.719	28.76	11.320	
	180	140.4	162.3	2.658	29.61	12.747	
	225	79.7	223.0	2.744	27.56	12.370	
	270	37.4	265.3	2.871	28.09	12.441	
	315	-5.0	307.7	3.385	29.38	12.011	
2041.9	0	-108.9	Ref.	2.846	30.67	13.583	I_{5V} = 93
	45	-169.1	60.2	2.798	27.27	12.081	
	90	148.3	102.8	2.280	27.64	12.413	I_{12V} = 44
	135	134.5	116.6	2.711	30.28	13.875	
	180	89.9	161.2	2.398	30.93	15.458	
	225	30.7	220.4	2.467	28.84	13.311	
	270	-11.9	263.0	2.376	29.35	13.329	
	315	-52.5	303.6	3.129	30.44	13.891	
2052.9	0	-162.7	Ref.	2.118	31.33	13.355	I_{5V} = 93
	45	143.1	54.2	2.410	28.31	13.805	
	90	99.2	98.1	2.027	28.74	14.310	I_{12V} = 44
	135	79.6	117.7	2.680	32.01	16.409	
	180	28.7	168.6	2.009	32.25	15.347	
	225	-22.0	219.3	2.027	30.05	14.288	
	270	-64.7	262.0	1.763	29.96	13.757	
	315	-107.5	304.8	2.486	31.45	14.209	

*Current measured at 0° phase setting only.
**Only 0° setting is measured on center modules (P/N SK446962-1)

SIZE	CODE IDENT NO	DRAWING NO
A	96214	SKDD302

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TABLE II. SPACS II MODULE RECORDED RECEIVER PHASE AND GAIN DATA
(CONTINUED)

INPUT POWER LEVEL = -40 DBM

FREQUENCY MHZ	COMMANDED PHASE SETTING DEGREES	MEASURED ** PHASE SETTING DEGREES ϕ	$\Delta\phi$	INPUT VSWR	GAIN DB	TIME DELAY NSEC	POWER SUPPLY* CURRENTS MA
2074.15	0	88.0	Ref.	1.353	31.03	13.063	I_{5V} = 93
	45	29.5	58.5	1.344	29.24	13.384	
	90	-15.4	103.4	1.606	30.14	14.245	I_{12V} = [illegible]
	135	-50.8	138.8	1.607	32.23	13.640	
	180	-91.1	179.1	1.641	31.02	12.470	
	225	-133.6	221.6	1.419	29.65	11.941	
	270	-170.8	258.8	1.472	30.02	12.343	
	315	139.7	308.3	1.211	31.56	13.735	
2095.4	0	-10.6	Ref.	2.367	29.57	13.008	I_{5V} = 93
	45	-71.2	60.6	1.953	26.79	11.622	
	90	-118.8	108.2	2.369	27.87	11.510	I_{12V} = 44
	135	-148.0	137.4	1.953	28.66	11.075	
	180	175.9	173.5	2.537	28.60	12.003	
	225	136.0	212.4	2.318	27.24	11.625	
	270	93.5	255.9	2.584	28.62	11.744	
	315	39.3	310.1	2.090	29.37	11.740	
2106.4	0	-62.1	Ref.	2.039	30.03	15.490	I_{5V} = 93
	45	-117.3	55.2	1.653	26.91	13.752	
	90	-164.4	102.1	1.933	27.52	14.599	I_{12V} = 44
	135	168.2	129.7	1.639	28.50	14.219	
	180	128.4	169.5	2.272	28.97	15.120	
	225	90.0	207.9	2.069	27.78	13.705	
	270	46.9	251.0	2.721	29.51	15.219	
	315	-7.2	305.1	1.927	29.40	14.639	

*Current measured at 0° phase setting only.
**Only 0° setting is measured on center modules (P/N SK446962-1)

SIZE	CODE IDENT NO	DRAWING NO
A	96214	SKDD302
SCALE	REV	SHEET 6

TABLE II. SPACS II MODULE RECORDED RECEIVER PHASE AND GAIN DATA (CONTINUED)

INPUT POWER LEVEL = -40 DBM

FREQUENCY MHZ	COMMANDED PHASE SETTING DEGREES	MEASURED** PHASE SETTING DEGREES	$\Delta\phi$	INPUT VSWR	GAIN DB	TIME DELAY NSEC	POWER SUPPLY* CURRENT MA
2117.4	0	-123.5	Ref.	1.637	30.38	17.761	I_{5V} = 93
	45	-171.7	48.2	1.484	27.04	17.051	
	90	137.8	98.7	1.413	28.14	16.710	I_{12V} = 44
	135	111.9	124.6	1.288	29.52	17.736	
	180	68.5	168.0	1.610	30.35	18.942	
	225	35.7	200.8	1.589	28.82	17.578	
	270	-13.3	249.8	2.018	30.29	17.738	
	315	-65.2	301.7	1.682	30.20	16.959	

*Current measured at 0° phase setting only.

**Only 0° setting is measured on center modules (P/N SK446962-1)

SIZE	CODE IDENT NO	DRAWING NO
A	96214	SKD0302

SCALE REV SHEET 7 4

TABLE III. SPACS II MODULE ADDITIONAL RECEIVER TEST DATA
(NOISE FIGURE AND COMPRESSION AT
ROOM TEMPERATURE ONLY)

FREQUENCY MHZ	RECEIVER NOISE FIGURE DB	RECEIVER NOISE TEMPERATURE °K	RECEIVER OUTPUT 1 DB COMPRESSION POINT DBM	ANTENNA PORT INPUT POWER LEVEL DBM	RECEIVER GAIN DB
2030.9	6.0	865	+2.15	-29.64	31.79
2041.9	6.2	919	+1.11	-31.67	32.78
2052.9	6.2	919	+1.07	-34.69	35.76
2074.15	5.2	671	+0.97	-28.53	29.50
2095.4	5.0	627	+0.87	-28.75	29.62
2106.4	5.1	648	+1.84	-29.64	31.48
2117.4	5.2	671	+0.83	-32.16	32.99

TABLE IV. SPACS II MODULE DUPLEX EVALUATION
TESTS FOR RECEIVER COMPRESSION

RECEIVE LEVEL (DBM)		TRANSMIT LEVEL (DBM)		FREQUENCY (MHZ)	LOAD VSWR
AT ANTENNA	AT RCV OUTPUT	AT ANTENNA	AT RCV OUTPUT	XMIT/RCV	
-40	-7.0	--	—	OFF/2041.9	1.6:1
-40	-9.0	> +35	+10.0	2217.5/2041.9	1.6:1
-40	-7.5	--	—	OFF/2106.4	1.6:1
-40	-8.0	> +35	-8.0	2287.5/2106.4	1.6:1

SIZE	CODE IDENT NO	DRAWING NO	
A	96214	SKDD302	
SCALE	REV		SHEET 8

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TABLE IV. DUPLEX OPERATION CONTINUED, INTERMODULATION PRODUCT EVALUATION (ROOM TEMPERATURE) SUMMARY

FREQUENCY (MHZ) XMIT/RCVR	LOAD VSWR	INTERMODULATION FREQUENCY/DBC F1/IM1	F2/IM2	F3/IM3	F4/IM4
2217.5/2041.9	1.05:1	> 30	> 40	> 40	—
2217.5/2041.9	1.6:1	> 30	2390 MHz > 20	> 40	—
2287.5/2106.4	1.05:1	> 40	> 40	> 40	—
2287.5/2106.4	1.6:1	> 30	> 40	> 40	—

SIZE	CODE IDENT NO	DRAWING NO
A	96214	SKDD302

SCALE | REV | SHEET 9 4

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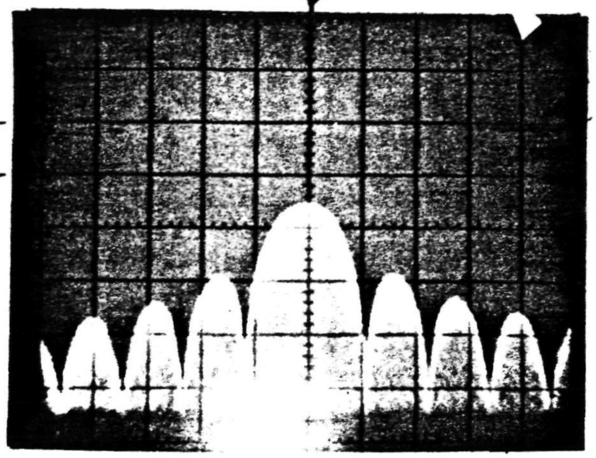
TABLE V. SPACS II MODULE - DUPLEX OPERATION, PULSE MODULATION TESTS, PHOTOGRAPHS

2041.9 MHZ

10 dB/Div.



(A)

TRANSMITTER OFF

RECEIVE CARRIER
f_R=2041.9 MHZ

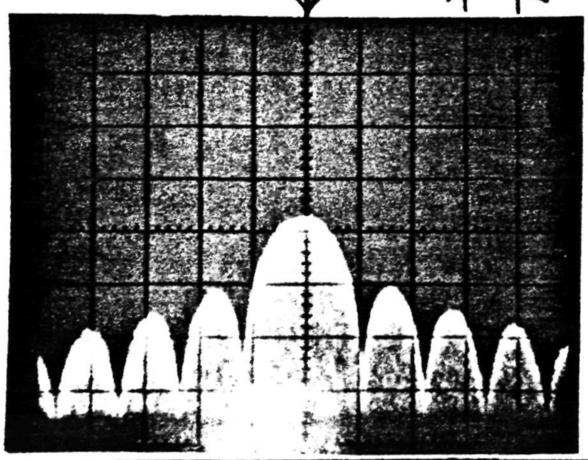
INPUT = -40 DBM

OUTPUT = -7.0 DBM

4.6 MHZ

2041.9 MHZ

1 MHZ/Div



(B)

TRANSMITTER ON
f_T=2217.5 MHZ

RECEIVE CARRIER
f_R=2041.9 MHZ

INPUT = -40 DBM

OUTPUT = -9.0 DBM

SIZE	CODE IDENT NO	DRAWING NO
A	96214	SKDD302

SCALE	REV	SHEET 10	4

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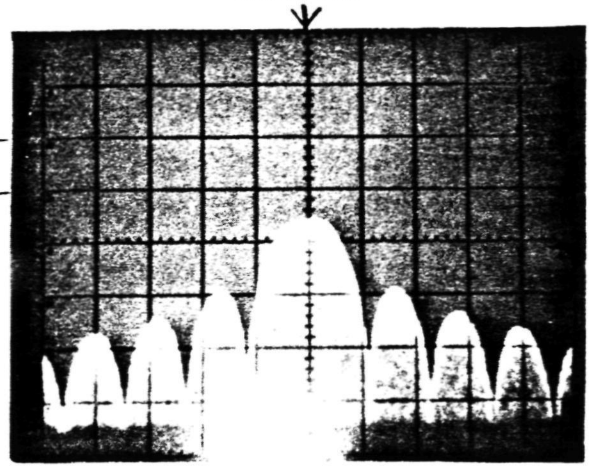
TABLE V. PULSED MODULATION PHOTOGRAPHS CONTINUED

2106.4 MHZ

10 dB/Div.



(C)

TRANSMITTER OFF

RECEIVE CARRIER
f_R=2106.4 MHZ

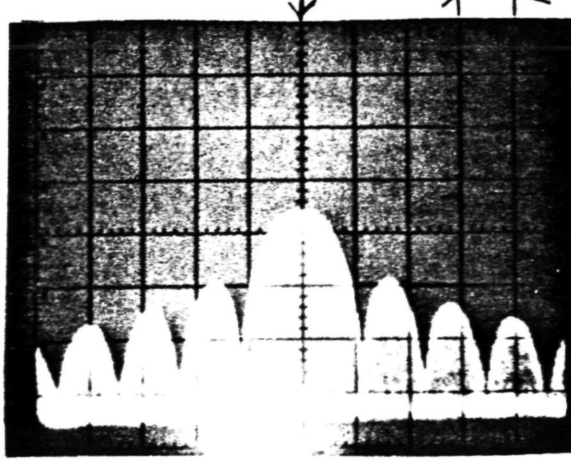
INPUT = -40 DBM

OUTPUT = -7.5 DBM

4.6 MHZ

2106.4 MHZ

1 MHz/Div



(D)

TRANSMITTER ON
f_T=2287.5 MHZ

RECEIVE CARRIER
f_R=2106.4 MHZ

INPUT = -40 DBM

OUTPUT = -8.0 DBM

SIZE	CODE IDENT NO	DRAWING NO
A	96214	SKDD302
SCALE	REV	SHEET 11

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TABLE VI. SPACS II MODULE SUMMARY OF L-BAND RECEIVER SECTION OF MODULE

FREQUENCY MHZ	ANTENNA CONNECTOR POWER LEVEL DBM	L-BAND INSERTION LOSS DB	CORRESPONDING NOISE TEMPERATURE K°
1600	N.A.	N.A.	N.A.
1775.5			
1803.65			
1831.8			
2000			

SIZE	CODE IDENT NO	DRAWING NO
A	96214	SKDD302
SCALE	REV	SHEET 12

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APPLICATION	
NEXT ASSY	USED ON
SK784010-1	1207
SK446962-1	1207

REVISIONS			
LTR	DESCRIPTION	DATE	APPROVED

SPACS II - TRANSMIT/RECEIVE MICROELECTRONICS MODULE

MEASUREMENT DATA SHEETS FOR OUTER MODULES

(P/N SK784010-1) AND FOR CENTER MODULES

(P/N SK446962-1)

REF: NASA/JSC HOUSTON, TEXAS

CONTRACT: NAS9-14485

A/T Final Data: 8-1-75

MODULE PART NUMBER SK 784010-1 (RECORD)

MODULE SERIAL NUMBER 005 (RECORD)

DRP

REV	
SHEET	
REV STATUS OF SHEETS	REV
	SHEET

UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES TOLERANCES ANGLES ±1° 3 PLACE DECIMAL±.010 2 PLACE DECIMAL±.02

IDENTIFYING NUMBERS SHOWN IN PARENTHESES FOR REFERENCE ONLY

INTERPRET DWG IN ACCORDANCE WITH MIL-STD-100

DWN D. Harbison DATE 5-9-75

CHK

ENGR D. Pezer 5-15-75

QA

APVD

CONTR NO

DESIGN ACTIVITY RELEASE

TEXAS INSTRUMENTS INCORPORATED Equipment Group Dallas, Texas

SPACS II-TRANSMIT/RECEIVE MICROELECTRONICS MODULE MEASUREMENT DATA SHEETS

SIZE	CODE IDENT NO	DRAWING NO
A	96214	SKDD302
SCALE		SHEET 1 OF 12

TI-9929-C

TABLE I. SPACS II MODULE RECORDED TRANSMITTER DATA
(ROOM TEMPERATURE ONLY)

INPUT POWER LEVEL = +12 DBM

FREQUENCY MHZ	COMMANDED PHASE SETTING DEGREES	MEASURED ** PHASE SETTING DEGREES	Δφ	INPUT VSWR	POWER OUTPUT DBM	GAIN DB	POWER SUPPLY* CURRENTS MA
2217.5	0	64.6	Ref.	1.404	35.18	2 .19	I_{5V} = 99
	45	20.6	44.0	1.348	35.19	23.20	
	90	-36.3	100.9	1.579	35.29	23.3	I_{12V} = 34
	135	-71.7	136.3	1.409	35.18	23.19	
	180	-134.5	199.1	1.326	35.17	23.18	
	225	-171.1	235.7	1.142	35.23	23.25	I_{22V} = 960
	270	137.2	287.4	1.363	35.25	23.26	
	315	100.7	323.9	1.317	35.17	23.19	
2257.5	0	-125.0	Ref.	1.221	35.09	23.09	I_{5V} = 99
	45	-170.4	45.4	1.373	35.15	23.16	
	90	144.9	90.1	1.123	35.08	23.08	I_{12V} = 34
	135	98.7	136.3	1.350	34.95	22.95	
	180	47.2	187.8	1.109	35.08	23.08	
	225	1.4	233.6	1.254	35.24	23.24	I_{22V} = 830
	270	-45.0	280.0	1.209	35.06	23.06	
	315	-90.3	325.3	1.562	35.01	23.01	
2287.5	0	109.8	Ref.	1.453	33.8	21.8	I_{5V} = 99
	45	65.1	44.7	1.493	33.9	21.9	
	90	13.0	96.8	1.204	34.11	22.12	I_{12V} = 34
	135	-31.0	140.8	1.497	33.7	21.72	
	180	-82.2	192.0	1.073	34.02	22.03	I_{22V} = 570
	225	-125.1	234.9	1.318	33.95	21.96	
	270	-171.9	281.7	1.320	34.03	22.04	
	315	146.3	323.5	1.495	33.71	21.72	

*Current measured at 0° phase setting only.

**Only 0° setting is measured on center modules (P/N SK446962-1)

SIZE	CODE IDENT NO	DRAWING NO
A	96214	SKKDD302
SCALE	REV	SHEET 2

TI-7915C

TABLE I. SPACS II MODULE RECORDED TRANSMITTER DATA
(CONTINUED

INPUT POWER LEVEL = +13 DBM

FREQUENCY MHZ	COMMANDED PHASE SETTING DEGREES	MEASURED ** PHASE SETTING DEGREES	$\Delta\phi$	INPUT VSWR	POWER OUTPUT DBM	GAIN DB	POWER SUPPLY* CURRENTS MA
2217.5	0	65.3	Ref.	1.459	35.15	22.15	I_{5V} = 99
	45	21.6	43.7	1.335	35.13	22.13	
	90	-35.5	100.8	1.581	35.25	22.25	I_{12V} = 34
	135	-70.1	135.4	1.450	35.14	22.14	
	180	-133.4	198.7	1.426	35.10	22.10	I_{22V} = 960
	225	-170.5	235.8	1.279	35.18	22.18	
	270	137.9	287.4	1.391	35.22	22.22	
	315	102.0	323.3	1.298	35.13	22.13	
2257.5	0	-123.9	Ref.	1.157	35.12	22.16	I_{5V} = 99
	45	-169.1	45.2	1.208	35.21	22.24	
	90	145.2	90.9	1.015	35.09	22.12	I_{12V} = 34
	135	100.8	135.3	1.279	34.92	21.96	
	180	48.1	188.0	1.190	35.07	22.11	I_{22V} = 840
	225	2.6	233.5	1.356	35.31	22.35	
	270	-44.3	280.4	1.220	35.08	22.11	
	315	-88.1	324.2	1.436	34.97	22.01	
2287.5	0	108.8	Ref.	1.354	34.03	21.07	I_{5V} = 99
	45	63.1	45.7	1.285	34.17	21.21	
	90	12.4	96.4	1.287	34.21	21.24	I_{12V} = 34
	135	-31.0	139.8	1.465	33.90	20.94	
	180	-82.7	191.5	1.146	34.15	21.18	I_{22V} = 610
	225	-126.7	235.5	1.274	34.17	21.21	
	270	-172.3	281.1	1.393	34.12	21.16	
	315	146.1	322.7	1.424	33.92	20.96	

*Current measured at 0° phase setting only.

**Only 0° setting is measured on center modules (P/N SK446962-1)

SIZE	CODE IDENT NO	DRAWING NO
A	96214	SKDD302
SCALE	REV	SHEET 3 5

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TABLE I. SPACS II MODULE RECORDED TRANSMITTER DATA (CONTINUED)

INPUT POWER LEVEL = +14 DBM

FREQUENCY MHZ	COMMANDED PHASE SETTING DEGREES	MEASURED ** PHASE SETTING DEGREES	Δφ	INPUT VSWR	POWER OUTPUT DBM	GAIN DB	POWER SUPPLY* CURRENTS MA
2217.5	0	65.9	Ref.	1.537	35.16	21.12	I_{5V} = 99
	45	22.3	43.6	1.426	35.14	[illegible]	
	90	-35.0	100.9	1.533	35.23	21.19	I_{12V} = 34
	135	-6[illegible].1	135.0	1.457	35.12	21.09	
	180	-132.7	198.6	1.542	35.09	21.05	I_{22V} = 960
	225	-169.4	235.3	1.385	35.16	21.13	
	270	138.6	287.3	1.458	35.20	21.17	
	315	103.2	322.7	1.339	35.14	21.10	
2252.5	0	-122.5	Ref.	1.220	35.16	21.20	I_{5V} = 99
	45	-167.5	45.0	1.185	35.24	21.27	
	90	145.5	92.0	1.116	35.11	21.14	I_{12V} = 34
	135	102.6	134.9	1.283	34.91	20.94	
	180	48.8	188.7	1.312	35.08	21.11	I_{22V} = 850
	225	4.5	233.0	1.469	35.33	21.3[illegible]	
	270	-43.0	280.5	1.312	35.09	21.12	
	315	-85.4	322.9	1.414	34.97	21.01	
2287.5	0	108.7	Ref.	1.374	34.21	20.21	I_{5V} = 99
	45	62.2	46.5	1.226	34.34	20.34	
	90	11.8	96.9	1.348	34.29	20.29	I_{12V} = 34
	135	-30.4	139.1	1.485	34.02	20.0[illegible]	
	180	-83.0	191.7	1.297	34.25	20.25	I_{22V} = 650
	225	-126.3	235.0	1.357	34.32	20.32	
	270	-172.3	281.0	1.520	34.20	20.20	
	315	146.9	321.8	1.469	34.05	20.05	

*Current measured at 0° phase setting only.

** Only 0° setting is measured on center modules (P/N SK 446962-1)

SIZE	CODE IDENT NO	DRAWING NO
A	96214	SKDD302
SCALE	REV	SHEET 4

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TABLE II. SPACS II MODULE RECORDED RECEIVER PHASE AND GAIN DATA (ROOM TEMPERATURE ONLY)

INPUT POWER LEVEL = -40 DBM

FREQUENCY MHZ	COMMANDED PHASE SETTING DEGREES	MEASURED ** PHASE SETTING DEGREES	$\Delta\phi$	INPUT VSWR	GAIN DB	TIME DELAY NSEC	POWER SUPPLY* CURRENTS MA
2030.9	0	-98.4	Ref.	1.527	31.2	16.078	I_{5V} = 97
	45	-144.0	45.6	1.601	30.9	16.739	
	90	-176.0	77.6	1.738	28.0	17.035	I_{12V} = 35
	135	145.4	116.2	1.816	29.4	17.329	
	180	81.2	180.4	1.858	31.1	16.455	
	225	34.9	226.7	1.792	31.2	16.476	
	270	-3.6	265.2	1.783	28.4	16.376	
	315	-40.9	302.5	1.766	29.6	16.994	
2041.9	0	-162.1	Ref.	1.301	32.0	14.907	I_{5V} = 97
	45	149.7	48.2	1.345	32.2	14.894	
	90	116.5	81.4	1.330	29.8	15.197	I_{12V} = 35
	135	76.8	121.1	1.354	30.96	15.849	
	180	16.0	181.9	1.254	32.2	14.424	
	225	-30.4	228.3	1.181	32.8	14.571	
	270	-68.5	266.4	1.199	30.2	14.994	
	315	-108.2	306.1	1.220	31.2	15.737	
2052.9	0	138.9	Ref.	1.711	32.61	13.797	I_{5V} = 97
	45	90.8	48.1	1.718	32.75	14.470	
	90	56.4	82.5	1.696	29.88	14.191	I_{12V} = 35
	135	14.0	124.9	1.691	30.9	13.867	
	180	-41.1	180.0	1.486	32.7	13.210	
	225	-88.1	227.0	1.435	33.2	13.959	
	270	-127.8	266.7	1.554	30.3	14.151	
	315	-170.5	309.4	1.625	30.99	14.138	

*Current measured at 0° phase setting only.
**Only 0° setting is measured on center modules (P/N SK446962-1)

SIZE	CODE IDENT NO	DRAWING NO
A	96214	SKDD302

SCALE | REV | SHEET 5 | 5

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TABLE II. SPACS II MODULE RECORDED RECEIVER PHASE AND GAIN DATA (CONTINUED)

INPUT POWER LEVEL = -40 DBM

FREQUENCY MHZ	COMMANDED PHASE SETTING DEGREES	MEASURED ** PHASE SETTING DEGREES	$\Delta\phi$	INPUT VSWR	GAIN DB	TIME DELAY NSEC	POWER SUPPLY* CURRENTS MA
2074.15	0	27.2	Ref.	1.252	32.8	13.614	I_{5V} = 97
	45	-22.3	49.5	1.243	32.2	12.8[illegible]	
	90	-52.7	79.9	1.273	29.6	12.555	I_{12V} = 35
	135	-92.8	120.0	1.260	30.6	13.063	
	180	-148.0	175.2	1.140	32.9	14.008	
	225	159.7	227.5	1.038	32.7	13.083	
	270	122.5	264.7	1.181	29.96	12.514	
	315	81.8	305.4	1.227	30.7	12.937	
2095.4	0	-77.0	Ref.	1.255	31.95	14.403	I_{5V} = 97
	45	-122.6	45.6	1.326	31.0	14.614	
	90	-152.2	75.2	1.396	28.8	14.583	I_{12V} = 35
	135	163.1	119.9	1.488	30.2	14.695	
	180	106.7	176.3	1.498	32.2	14.185	
	225	59.0	224.0	1.386	31.5	13.980	
	270	23.9	259.1	1.281	29.1	13.650	
	315	-18.8	301.8	1.260	30.4	13.835	
2106.4	0	-134.0	Ref.	1.772	31.5	15.672	I_{5V} = 97
	45	179.5	46.5	1.773	30.8	15.319	
	90	150.0	76.0	1.741	29.3	15.781	I_{12V} = 35
	135	104.9	121.1	1.685	30.96	17.015	
	180	50.5	175.5	1.446	31.9	15.457	
	225	3.7	222.3	1.342	31.5	14.989	
	270	-30.1	256.1	1.426	29.6	15.330	
	315	-73.5	299.5	1.483	30.95	16.505	

*Current measured at 0° phase setting only.

**Only 0° setting is measured on center modules (P/N SK446962-1)

SIZE	CODE IDENT NO	DRAWING NO
A	96214	SKDD302
SCALE	REV	SHEET 6

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TABLE II. SPACS II MODULE RECORDED RECEIVER PHASE AND GAIN DATA (CONTINUED)

INPUT POWER LEVEL = -40 DBM

FREQUENCY MHZ	COMMANDED PHASE SETTING DEGREES	MEASURED** PHASE SETTING DEGREES	$\Delta\phi$	INPUT VSWR	GAIN DB	TIME DELAY NSEC	POWER SUPPLY* CURRENT MA
2117.4	0	164.0	Ref.	3.723	29.6	12.128	I_{5V} = 97
	45	118.8	45.2	3.683	29.3	12.381	
	90	87.5	76.5	3.701	28.2	13.580	I_{12V} = 35
	135	37.6	126.4	3.481	29.3	13.~~455~~	
	180	-10.7	174.7	2.731	30.3	12.017	
	225	-55.7	219.7	2.737	30.1	12.273	
	270	-90.8	254.8	3.094	28.6	13.201	
	315	-138.9	302.9	3.517	29.6	13.991	

*Current measured at 0° phase setting only.

**Only 0° setting is measured on center modules (P/N SK446962-1)

SIZE	CODE IDENT NO	DRAWING NO
A	96214	SKDD302

SCALE | REV | SHEET 7 | 5

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TABLE III. SPACS II MODULE ADDITIONAL RECEIVER TEST DATA (NOISE FIGURE AND COMPRESSION AT ROOM TEMPERATURE ONLY)

FREQUENCY MHZ	RECEIVER NOISE FIGURE DB	RECEIVER NOISE TEMPERATURE °K	RECEIVER OUTPUT 1 DB COMPRESSION POINT DBM	ANTENNA PORT INPUT POWER LEVEL DBM	RECEIVER GAIN DB
2030.9	7.10	1197	+3.75	-28.4	32.15
2041.9	6.05	878	+4.57	-29.5	34.09
2052.9	5.9	838	+3.63	-28.3	31.93
2074.15	6.6	1036	+0.07	-23.9	23.97
2095.4	6.2	919	+5.83	-26.2	32.03
2106.4	5.8	812	+8.06	-27.6	35.66
2117.4	5.85	825	+3.67	-24.2	27.87

TABLE IV. SPACS II MODULE DUPLEX EVALUATION TESTS FOR RECEIVER COMPRESSION

RECEIVE LEVEL (DBM)		TRANSMIT LEVEL (DBM)		FREQUENCY (MHZ)	LOAD VSWR
AT ANTENNA	AT RCV OUTPUT	AT ANTENNA	AT RCV OUTPUT	XMIT/RCV	
-40	-8.0	--	—	OFF/2041.9	1.6:1
-40	-10.0	> +35	+6.0	2217.5/2041.9	1.6:1
-40	-8.5	--	—	OFF/2106.4	1.6:1
-40	-9.0	> +35	-3.0	2287.5/2106.4	1.6:1

SIZE	CODE IDENT NO	DRAWING NO
A	96214	SKDD302
SCALE	REV	SHEET 8

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TABLE IV. DUPLEX OPERATION CONTINUED, INTERMODULATION PRODUCT EVALUATION (ROOM TEMPERATURE) SUMMARY

FREQUENCY (MHZ) XMIT/RCVR	LOAD VSWR	INTERMODULATION FREQUENCY/DBC F1/IM1	F2/IM2	F3/IM3	F4/IM4
2217.5/2041.9	1.05:1	>30	>40	>40	—
2217.5/2041.9	1.6:1	>30	2390 MHz / >20	>40	—
2287.5/2106.4	1.05:1	>40	>40	>40	—
2287.5/2106.4	1.6:1	>30	>40	>40	—

SIZE	CODE IDENT NO	DRAWING NO
A	96214	SKDD302
SCALE	REV	SHEET 9 5

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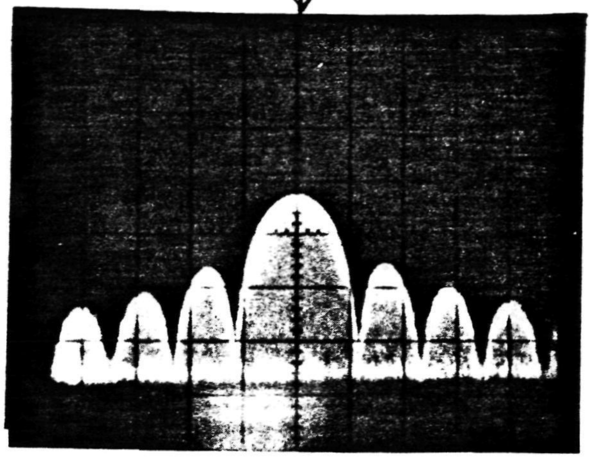
TABLE V. SPACS II MODULE - DUPLEX OPERATION, PULSE MODULATION TESTS, PHOTOGRAPHS

2041.9 MHZ

10 dB/Div



4.6 MHZ

(A)

TRANSMITTER OFF

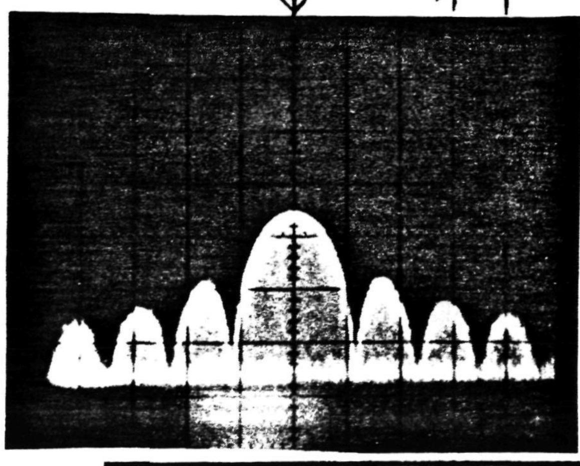
RECEIVE CARRIER
f_R=2041.9 MHZ

INPUT = -40 DBM

OUTPUT = -8.0 DBM

2041.9 MHZ

1 MHz/Div.



(B)

TRANSMITTER ON
f_T=2217.5 MHZ

RECEIVE CARRIER
f_R=2041.9 MHZ

INPUT = -40 DBM

OUTPUT = -10.0 DBM

SIZE	CODE IDENT NO	DRAWING NO	
A	96214	SKDD302	B-47
SCALE	REV	SHEET 10	5

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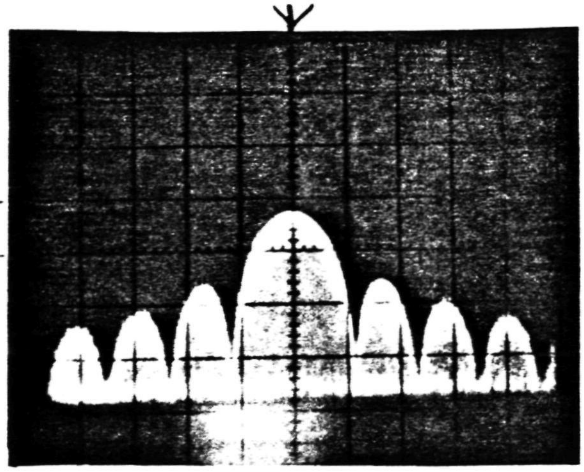
TABLE V. PULSED MODULATION PHOTOGRAPHS CONTINUED

2106.4 MHZ

10 dB/Div.

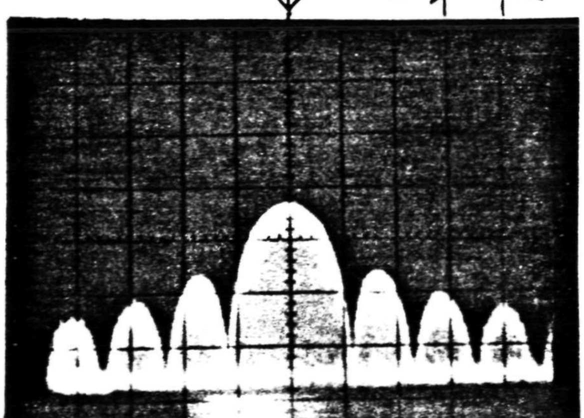


4.6 MHZ

(C)
TRANSMITTER OFF
RECEIVE CARRIER
f_R=2106.4 MHZ
INPUT = -40 DBM
OUTPUT = -8.5 DBM

2106.4 MHZ

1 MHz/Div



(D)
TRANSMITTER ON
f_T=2287.5 MHZ
RECEIVE CARRIER
f_R=2106.4 MHZ
INPUT = -40 DBM
OUTPUT = -8.0 DBM

SIZE	CODE IDENT NO	DRAWING NO
A	96214	SKDD302 B 47
SCALE	REV	SHEET 11

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TABLE VI. SPACS II MODULE SUMMARY OF L-BAND RECEIVER SECTION OF MODULE

FREQUENCY MHZ	ANTENNA CONNECTOR POWER LEVEL DBM	L-BAND INSERTION LOSS DB	CORRESPONDING NOISE TEMPERATURE K°
1600	N.A.	N.A.	N.A.
1775.5			
1803.65			
1831.8			
2000			

SIZE	CODE IDENT NO	DRAWING NO	
A	96214	SKDD302	B-48
SCALE	REV		SHEET 12

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APPLICATION		REVISIONS			
NEXT ASSY	USED ON	LTR	DESCRIPTION	DATE	APPROVED
SK784010-1	1207				
SK446962-1	1207				

SPACS II - TRANSMIT/RECEIVE MICROELECTRONICS MODULE

MEASUREMENT DATA SHEETS FOR OUTER MODULES

(P/N SK784010-1) AND FOR CENTER MODULES

(P/N SK446962-1)

REF: NASA/JSC HOUSTON, TEXAS

CONTRACT: NAS9-14485

A/T Final Data: 7-15-75

MODULE PART NUMBER SK784010-1 (RECORD)

MODULE SERIAL NUMBER 006 (RECORD)

DRD

REV	
SHEET	

REV STATUS OF SHEETS — REV / SHEET

UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES TOLERANCES ANGLES ±1° 3 PLACE DECIMAL ±.010 2 PLACE DECIMAL ±.02

IDENTIFYING NUMBERS SHOWN IN PARENTHESES FOR REFERENCE ONLY

INTERPRET DWG IN ACCORDANCE WITH MIL-STD-100

DWN D. Harrison DATE 5-9-75

CHK

ENGR D. Parker 5-15-75

QA

APVD

CONTR NO

DESIGN ACTIVITY RELEASE

TEXAS INSTRUMENTS INCORPORATED
Equipment Group Dallas, Texas

SPACS II-TRANSMIT/RECEIVE MICROELECTRONICS MODULE MEASUREMENT DATA SHEETS

SIZE	CODE IDENT NO	DRAWING NO
A	96214	SKDD302

SCALE | SHEET 1 OF 12

TI-0923-C

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TABLE I. SPACS II MODULE RECORDED TRANSMITTER DATA
(ROOM TEMPERATURE ONLY)

INPUT POWER LEVEL = +12 DBM

FREQUENCY MHZ	COMMANDED PHASE SETTING DEGREES	MEASURED ** PHASE SETTING DEGREES	ΔØ	INPUT VSWR	POWER OUTPUT DBM	GAIN DB	POWER SUPPLY* CURRENTS MA
2217.5	0	83.2	Ref.	1.659	34.97	22.97	I_{5V} = 101
	45	42.0	41.2	1.215	35.21	23.21	
	90	-2.2	85.4	2.082	34.63	22.64	I_{12V} = 41
	135	-40.5	123.7	2.090	34.76	22.76	
	180	-106.4	187.6	1.626	34.56	22.56	
	225	-144.6	227.8	1.151	34.83	22.83	I_{22V} = 720
	270	168.4	274.8	1.919	34.77	22.77	
	315	128.4	314.8	1.941	34.75	22.75	
2257.5	0	-139.8	Ref.	1.390	36.07	24.07	I_{5V} = 101
	45	175.2	45.0	2.069	35.81	23.81	
	90	136.1	84.1	1.396	35.68	23.68	I_{12V} = 42
	135	87.8	132.4	1.154	35.82	23.82	
	180	38.5	181.7	1.045	35.91	23.91	
	225	-7.9	228.1	1.359	35.79	23.80	I_{22V} = 770
	270	-47.3	269.5	1.175	35.65	23.65	
	315	-96.1	316.3	1.221	35.72	23.72	
2287.5	0	68.9	Ref.	1.690	35.61	23.61	I_{5V} = 101
	45	34.4	34.5	1.952	35.51	23.51	
	90	-25.4	94.3	1.348	35.28	23.29	I_{12V} = 41
	135	-66.0	134.9	1.294	35.25	23.25	
	180	-114.9	183.8	1.387	35.44	23.44	I_{22V} = 740
	225	-149.5	218.4	1.528	35.25	23.25	
	270	154.1	274.8	1.260	35.34	23.34	
	315	111.8	317.1	1.194	35.46	23.46	

*Current measured at 0° phase setting only.

**Only 0° setting is measured on center modules (P/N SK446962-1)

SIZE	CODE IDENT NO	DRAWING NO
A	96214	SKKDD302
SCALE	REV	SHEET 2

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TABLE I. SPACS II MODULE RECORDED TRANSMITTER DATA
(CONTINUED

INPUT POWER LEVEL = +13 DBM

FREQUENCY MHZ	COMMANDED PHASE SETTING DEGREES	MEASURED ** PHASE SETTING DEGREES	Δφ	INPUT VSWR	POWER OUTPUT DBM	GAIN DB	POWER SUPPLY* CURRENTS MA
2217.5	0	82.2	Ref.	1.823	34.96	21.95	I_{5V} = 101
	45	42.8	39.4	1.259	35.12	22.11	
	90	-12.5	94.7	2.055	35.06	22.05	I_{12V} = 41
	135	-43.3	125.5	2.071	34.91	21.90	
	180	-108.5	190.7	1.790	34.73	21.73	I_{22V} = 730
	225	-144.9	227.1	1.288	34.94	21.93	
	270	160.0	282.2	1.895	35.03	22.02	
	315	127.1	315.1	1.909	34.91	21.90	
2252.5	0	-138.9	Ref.	1.408	35.96	22.98	I_{5V} = 101
	45	176.1	45.0	1.615	35.83	22.85	
	90	134.5	86.6	1.282	35.73	22.75	I_{12V} = 42
	135	88.5	132.6	1.309	35.84	22.85	
	180	38.4	182.7	1.206	35.96	22.98	I_{22V} = 780
	225	-6.5	227.6	1.255	35.89	22.91	
	270	-49.0	270.1	1.150	35.74	22.76	
	315	-95.6	316.7	1.328	35.76	22.78	
2287.5	0	65.5	Ref.	1.552	35.70	22.73	I_{5V} = 101
	45	28.1	37.4	1.536	35.64	22.67	
	90	-27.1	92.6	1.483	35.33	22.36	I_{12V} = 41
	135	-66.3	131.8	1.436	35.34	22.37	
	180	-119.0	184.5	1.368	35.63	22.66	I_{22V} = 780
	225	-156.3	221.8	1.214	35.48	22.51	
	270	150.9	274.6	1.403	35.41	22.44	
	315	111.6	313.9	1.347	35.57	22.60	

*Current measured at 0° phase setting only.

**Only 0° setting is measured on center modules (P/N SK446962-1)

SIZE	CODE IDENT NO	DRAWING NO
A	96214	SKDD302
SCALE	REV	SHEET 3 6

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B-~~[illegible]~~
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TABLE I. SPACS II MODULE RECORDED TRANSMITTER DATA (CONTINUED)

INPUT POWER LEVEL = +14 DBM

FREQUENCY MHZ	COMMANDED PHASE SETTING DEGREES	MEASURED ** PHASE SETTING DEGREES	$\Delta\phi$	INPUT VSWR	POWER OUTPUT DBM	GAIN DB	POWER SUPPLY* CURRENTS MA
2217.5	0	82.7	Ref.	1.989	34.85	2[illegible].85	I_{5V} = 101
	45	44.4	38.3	1.404	34.97	20.99	
	90	-13.4	96.1	1.914	35.02	21.03	I_{12V} = 41
	135	-43.6	126.3	2.055	34.93	20.94	
	180	-108.0	190.7	1.965	34.69	20.71	I_{22V} = 740
	225	-143.5	226.2	1.463	34.85	20.86	
	270	160.3	282.4	1.806	34.99	21.00	
	315	127.3	315.4	1.900	34.85	20.86	
225[illegible].5	0	-137.9	Ref.	1.559	35.91	21.93	I_{5V} = 101
	45	177.8	44.3	1.454	35.86	21.88	
	90	133.3	88.8	1.257	35.77	21.79	I_{12V} = 42
	135	89.4	132.7	1.485	35.82	21.84	
	180	38.8	183.3	1.384	35.97	21.99	I_{22V} = 790
	225	-5.0	227.1	1.327	35.95	21.97	
	270	-49.6	271.7	1.251	35.74	21.76	
	315	-94.7	316.8	1.510	35.71	21.73	
2287.5	0	66.6	Ref.	1.656	35.72	21.72	I_{5V} = 101
	45	27.8	38.8	1.289	35.64	21.70	
	90	-27.7	94.3	1.611	35.35	21.36	I_{12V} = 41
	135	-65.5	132.1	1.628	35.40	21.41	
	180	-118.2	184.8	1.516	35.67	21.67	I_{22V} = 800
	225	-155.8	222.4	1.225	35.59	21.59	
	270	149.0	277.6	1.585	35.45	21.46	
	315	112.4	314.2	1.551	35.59	21.60	

*Current measured at 0° phase setting only.

** Only 0° setting is measured on center modules (P/N SK 446962-1)

SIZE	CODE IDENT NO	DRAWING NO
A	96214	SKDD302

SCALE	REV	SHEET 4

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TABLE II. SPACS II MODULE RECORDED RECEIVER PHASE AND GAIN DATA
(ROOM TEMPERATURE ONLY)

INPUT POWER LEVEL = -40 DBM

FREQUENCY MHZ	COMMANDED PHASE SETTING DEGREES	MEASURED ** PHASE SETTING DEGREES	Δφ	INPUT VSWR	GAIN DB	TIME DELAY NSEC	POWER SUPPLY* CURRENTS MA
2030.9	0	-78.2	Ref.	1.797	32.18	13.98	I_{5V} = 100
	45	-122.1	43.9	1.877	32.59	14.66	
	90	-160.9	82.7	1.618	32.01	14.87	I_{12V} = 42
	135	157.6	124.2	1.598	31.28	13.96	
	180	103.6	178.2	1.649	31.90	13.33	
	225	62.3	219.5	1.683	32.23	13.90	
	270	15.0	266.8	1.657	32.21	13.94	
	315	-26.3	308.1	1.693	31.86	13.75	
2041.9	0	-133.6	Ref.	1.315	33.11	15.94	I_{5V} = 100
	45	179.8	46.6	1.354	33.17	15.42	
	90	140.2	86.2	1.343	32.35	14.36	I_{12V} = 42
	135	102.3	124.1	1.351	31.92	14.47	
	180	50.7	175.7	1.395	32.27	14.49	
	225	7.3	219.1	1.445	32.95	14.67	
	270	-40.2	266.6	1.438	32.98	14.64	
	315	-80.8	307.2	1.487	32.66	14.95	
2052.9	0	163.2	Ref.	1.908	33.22	13.21	I_{5V} = 100
	45	118.7	44.5	1.769	33.58	12.98	
	90	83.3	79.9	1.714	32.79	13.50	I_{12V} = 42
	135	45.0	118.2	1.682	32.50	13.99	
	180	-6.7	169.9	1.556	33.29	13.54	
	225	-50.8	214.0	1.580	34.24	14.09	
	270	-98.1	261.3	1.643	33.81	14.06	
	315	-140.0	303.2	1.666	33.34	14.61	

*Current measured at 0° phase setting only.
**Only 0° setting is measured on center modules (P/N SK446962-1)

SIZE	CODE IDENT NO	DRAWING NO
A	96214	SKDD302

SCALE | REV | SHEET 5 6

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TABLE II. SPACS II MODULE RECORDED RECEIVER PHASE AND GAIN DATA
(CONTINUED)

INPUT POWER LEVEL = -40 DBM

FREQUENCY MHZ	COMMANDED PHASE SETTING DEGREES	MEASURED ** PHASE SETTING DEGREES	$\Delta\phi$	INPUT VSWR	GAIN DB	TIME DELAY NSEC	POWER SUPPLY* CURRENTS MA
2074.15	0	65.9	Ref.	2.44	33.09	12.32	I_{5V} = 100
	45	19.6	46.3	2.39	32.55	12.55	
	90	-17.8	83.7	2.79	32.11	12.35	I_{12V} = 42
	135	-59.2	125.1	2.92	32.37	12.74	
	180	-107.6	173.5	2.68	32.89	12.68	
	225	-156.8	222.7	2.54	33.11	13.09	
	270	156.5	269.4	2.58	32.36	12.12	
	315	114.1	311.8	2.58	32.23	11.99	
2095.4	0	-33.8	Ref.	1.289	33.88	16.92	I_{5V} = 100
	45	-82.7	48.9	1.571	33.57	14.44	
	90	-119.8	86.0	1.753	32.80	14.55	I_{12V} = 42
	135	-164.8	131.0	1.828	32.37	14.04	
	180	148.7	177.5	1.737	32.93	12.86	
	225	101.6	224.6	1.637	32.99	12.78	
	270	58.8	267.4	1.609	32.41	13.24	
	315	15.7	310.5	1.604	32.21	12.90	
2106.4	0	-88.7	Ref.	1.289	33.88	16.92	I_{5V} = 100
	45	-139.9	51.2	1.255	33.58	16.78	
	90	-177.4	88.7	1.483	32.63	15.65	I_{12V} = 42
	135	139.7	131.6	1.561	32.38	14.59	
	180	97.7	173.6	1.507	33.01	14.71	
	225	50.9	220.4	1.459	32.81	14.71	
	270	6.4	264.9	1.418	32.65	14.74	
	315	-35.4	306.7	1.412	32.69	14.75	

*Current measured at 0° phase setting only.
**Only 0° setting is measured on center modules (P/N SK446962-1)

SIZE	CODE IDENT NO	DRAWING NO
A	96214	SKDD302
SCALE	REV	SHEET 6

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TABLE II. SPACS II MODULE RECORDED RECEIVER PHASE AND GAIN DATA (CONTINUED)

INPUT POWER LEVEL = -40 DBM

FREQUENCY MHZ	COMMANDED PHASE SETTING DEGREES	MEASURED** PHASE SETTING DEGREES	$\Delta\phi$	INPUT VSWR	GAIN DB	TIME DELAY NSEC	POWER SUPPLY* CURRENT MA
2117.4	0	-155.7	Ref.	1.577	33.45	16.95	I_{5V} = 100
	45	153.6	50.7	1.545	33.01	15.47	
	90	120.6	83.7	1.432	32.39	15.19	I_{12V} = 42
	135	81.9	122.4	1.328	32.16	15.65	
	180	39.4	164.9	1.226	32.80	15.44	
	225	-7.3	211.6	1.199	33.15	15.60	
	270	-52.0	256.3	1.299	33.00	15.79	
	315	-93.8	298.1	1.303	33.06	16.58	

*Current measured at 0° phase setting only.

**Only 0° setting is measured on center modules (P/N SK446962-1)

SIZE	CODE IDENT NO	DRAWING NO
A	96214	SKDD302
SCALE	REV	SHEET 7

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TABLE III. SPACS II MODULE ADDITIONAL RECEIVER TEST DATA (NOISE FIGURE AND COMPRESSION AT ROOM TEMPERATURE ONLY)

FREQUENCY MHZ	RECEIVER NOISE FIGURE DB	RECEIVER NOISE TEMPERATURE °K	RECEIVER OUTPUT 1 DB COMPRESSION POINT DBM	ANTENNA PORT INPUT POWER LEVEL DBM	RECEIVER GAIN DB
2030.9	5.95	852	+6.95	-23.94	30.89
2041.9	5.7	757	+8.31	-23.97	32.28
2052.9	5.5	739	+7.67	-27.89	35.56
2074.15	5.8	813	+8.47	-25.33	33.80
2095.4	5.1	648	+8.87	-25.63	34.50
2106.4	4.9	607	+8.84	-24.34	33.18
2117.4	4.8	586	+8.83	-24.46	33.29

TABLE IV. SPACS II MODULE DUPLEX EVALUATION TESTS FOR RECEIVER COMPRESSION

RECEIVE LEVEL (DBM)		TRANSMIT LEVEL (DBM)		FREQUENCY (MHZ)	LOAD VSWR
AT ANTENNA	AT RCV OUTPUT	AT ANTENNA	AT RCV OUTPUT	XMIT/RCV	
-40	-7.0	--	—	OFF/2041.9	1.6:1
-40	-11.0	> +35	+8.0	2217.5/2041.9	1.6:1
-40	-6.0	--	—	OFF/2106.4	1.6:1
-40	-6.0	> +35	-18.0	2287.5/2106.4	1.6:1

SIZE	CODE IDENT NO	DRAWING NO
A	96214	SKDD302
SCALE	REV	SHEET 8

TI-7915C

TABLE IV. DUPLEX OPERATION CONTINUED, INTERMODULATION PRODUCT EVALUATION (ROOM TEMPERATURE) SUMMARY

FREQUENCY (MHZ) XMIT/RCVR	LOAD VSWR	INTERMODULATION FREQUENCY/DBC F1/IM1	F2/IM2	F3/IM3	F4/IM4
2217.5/2041.9	1.05:1	>30	>40	>40	——
2217.5/2041.9	1.6:1	>30	2890 MHz / >20	>40	——
2287.5/2106.4	1.05:1	>40	>40	>40	——
2287.5/2106.4	1.6:1	>30	>40	>40	——

SIZE	CODE IDENT NO	DRAWING NO
A	96214	SKDD302
SCALE	REV	SHEET 9 6

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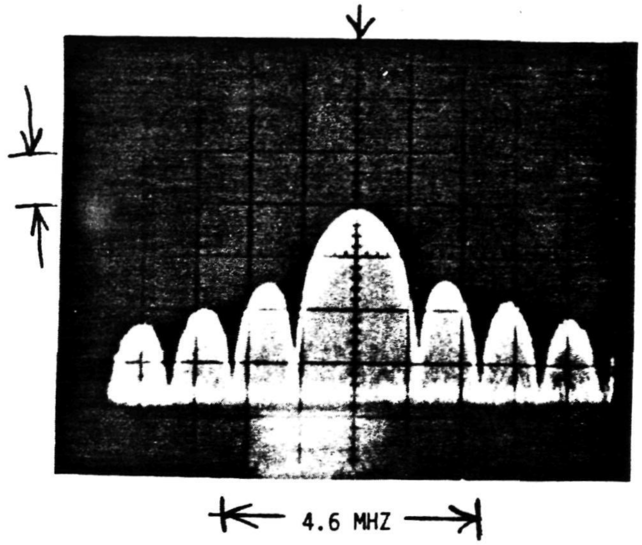
TABLE V. SPACS II MODULE - DUPLEX OPERATION, PULSE MODULATION TESTS, PHOTOGRAPHS



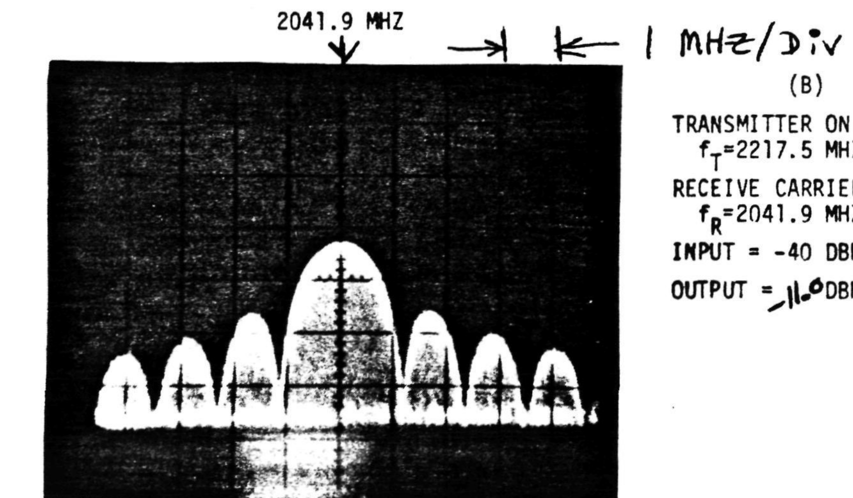
(A)

TRANSMITTER OFF

RECEIVE CARRIER
f_R=2041.9 MHZ

INPUT = -40 DBM

OUTPUT = -11.0 DBM



(B)

TRANSMITTER ON
f_T=2217.5 MHZ

RECEIVE CARRIER
f_R=2041.9 MHZ

INPUT = -40 DBM

OUTPUT = -11.0 DBM

SIZE	CODE IDENT NO	DRAWING NO
A	96214	SKDD302 B-58
SCALE	REV	SHEET 10 6

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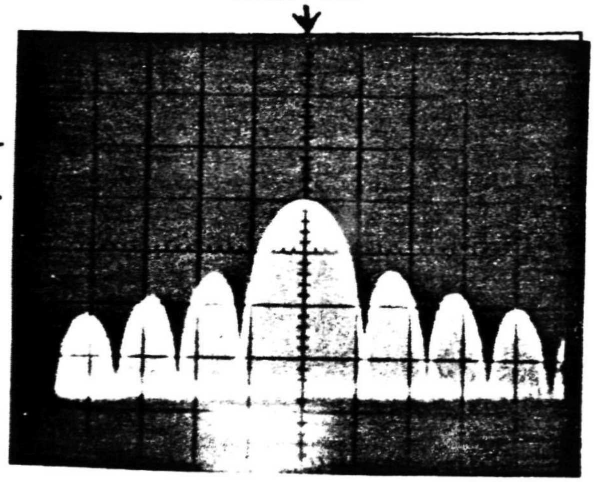
TABLE V. PULSED MODULATION PHOTOGRAPHS CONTINUED

2106.4 MHZ



10 dB/Div.

4.6 MHZ

(C)

TRANSMITTER OFF

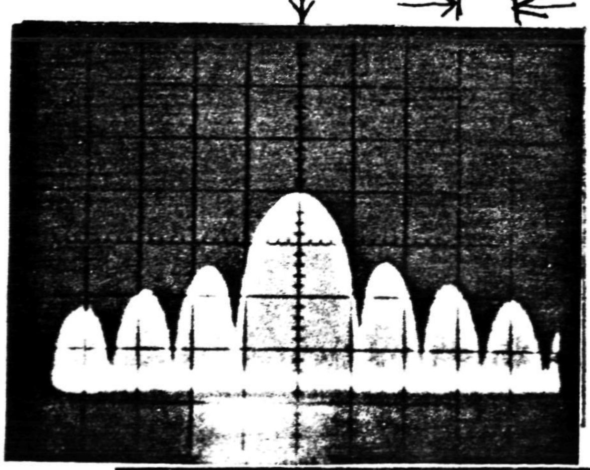
RECEIVE CARRIER
f_R=2106.4 MHZ

INPUT = -40 DBM

OUTPUT = -6.0 DBM

2106.4 MHZ

1 MHZ/Div.



(D)

TRANSMITTER ON
f_T=2287.5 MHZ

RECEIVE CARRIER
f_R=2106.4 MHZ

INPUT = -40 DBM

OUTPUT = -6.0 DBM

SIZE	CODE IDENT NO	DRAWING NO
A	96214	SKDD302 B-59
SCALE	REV	SHEET 11

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TABLE VI. SPACS II MODULE SUMMARY OF L-BAND RECEIVER SECTION OF MODULE

FREQUENCY MHZ	ANTENNA CONNECTOR POWER LEVEL DBM	L-BAND INSERTION LOSS DB	CORRESPONDING NOISE TEMPERATURE K°
1600	N. A.	N. A.	N. A.
1775.5			
1803.65			
1831.8			
2000			

SIZE	CODE IDENT NO	DRAWING NO
A	96214	SKDD302 B-60
SCALE	REV	SHEET 12

TI-7915C

APPLICATION	
NEXT ASSY	USED ON
SK784010-1	1207
SK446962-1	1207

REVISIONS			
LTR	DESCRIPTION	DATE	APPROVED

SPACS II - TRANSMIT/RECEIVE MICROELECTRONICS MODULE

MEASUREMENT DATA SHEETS FOR OUTER MODULES

(P/N SK784010-1) AND FOR CENTER MODULES

(P/N SK446962-1)

REF: NASA/JSC HOUSTON, TEXAS

CONTRACT: NAS9-14485

A/T Final Data: 8-1-75

MODULE PART NUMBER SK784010-1 (RECORD)

MODULE SERIAL NUMBER 007 (RECORD)

DRP

REV

SHEET

REV STATUS OF SHEETS — REV / SHEET

UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES TOLERANCES ANGLES ±1° 3 PLACE DECIMAL ±.010 2 PLACE DECIMAL ±.02

IDENTIFYING NUMBERS SHOWN IN PARENTHESES FOR REFERENCE ONLY

INTERPRET DWG IN ACCORDANCE WITH MIL-STD-100

DWN P. Harkison DATE 5-9-75

CHK

ENGR P. Peyer 5-15-75

QA

APVD

CONTR NO

DESIGN ACTIVITY RELEASE

TEXAS INSTRUMENTS INCORPORATED Equipment Group Dallas, Texas

SPACS II-TRANSMIT/RECEIVE MICROELECTRONICS MODULE MEASUREMENT DATA SHEETS

SIZE A | CODE IDENT NO 96214 | DRAWING NO SKDD302

SCALE | SHEET 1 OF 12

TI-0923-C P1

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TABLE I. SPACS II MODULE RECORDED TRANSMITTER DATA
(ROOM TEMPERATURE ONLY)

INPUT POWER LEVEL = +12 DBM

FREQUENCY MHZ	COMMANDED PHASE SETTING DEGREES	MEASURED ** PHASE SETTING DEGREES	$\Delta\phi$	INPUT VSWR	POWER OUTPUT DBM	GAIN DB	POWER SUPPLY* CURRENTS MA
2217.5	0	51.1	Ref.	1.644	35.81	23.83	I_{5V} = 102
	45	11.1	40.0	1.552	35.54	23.85	
	90	-52.5	103.6	1.088	35.62	23.64	I_{12V} = 34
	135	-86.6	137.7	1.367	35.59	23.60	
	180	-141.1	192.2	1.508	35.76	23.77	
	225	-179.4	230.5	1.418	35.78	23.75	I_{22V} = 1020
	270	134.9	276.2	1.132	35.64	23.66	
	315	96.6	314.5	1.242	35.79	23.80	
2257.5	0	-132.0	Ref.	1.723	36.00	24.20	I_{5V} = 102
	45	179.1	48.9	1.306	36.15	24.16	
	90	128.9	99.1	1.144	36.21	24.21	I_{12V} = 34
	135	85.6	142.4	1.466	36.23	24.22	
	180	35.5	192.5	1.455	36.21	24.21	
	225	-10.4	238.4	1.617	36.14	24.14	I_{22V} = 880
	270	-54.2	282.2	1.408	35.95	23.96	
	315	-96.5	324.5	1.995	36.10	24.10	
2287.5	0	91.8	Ref.	1.185	35.42	23.43	I_{5V} = 102
	45	42.6	49.2	1.702	35.05	23.06	
	90	-8.4	100.2	1.575	35.13	23.14	I_{12V} = 34
	135	-43.1	134.9	1.847	34.70	22.71	
	180	-85.2	177.0	1.401	34.83	22.85	I_{22V} = 730
	225	-145.7	237.5	1.774	34.99	23.00	
	270	171.6	280.2	2.142	34.93	22.95	
	315	148.0	303.8	2.456	34.26	22.27	

*Current measured at 0° phase setting only.

**Only 0° setting is measured on center modules (P/N SK446962-1)

SIZE	CODE IDENT NO	DRAWING NO
A	96214	SKKDD302
SCALE	REV	SHEET 2

TI-7915C

B ~~[illegible]~~
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TABLE I. SPACS II MODULE RECORDED TRANSMITTER DATA (CONTINUED

INPUT POWER LEVEL = +13 DBM

FREQUENCY MHZ	COMMANDED PHASE SETTING DEGREES	MEASURED ** PHASE SETTING DEGREES	Δφ	INPUT VSWR	POWER OUTPUT DBM	GAIN DB	POWER SUPPLY* CURRENTS MA
2217.5	0	51.5	Ref.	1.501	35.67	22.68	I_{5V} = 102
	45	11.8	39.7	1.576	35.72	22.73	
	90	-50.5	102.0	1.252	35.52	22.52	I_{12V} = 34
	135	-89.4	140.9	1.212	35.51	22.52	
	180	-139.4	190.9	1.351	35.65	22.65	I_{22V} = 1020
	225	-177.2	228.7	1.368	35.63	22.63	
	270	136.7	274.8	1.303	35.54	22.54	
	315	99.0	312.5	1.129	35.63	22.64	
2257.5	0	-133.7	Ref.	1.422	36.14	23.13	I_{5V} = 102
	45	179.8	46.5	1.219	36.06	23.06	
	90	129.3	97.0	1.047	36.11	23.10	I_{12V} = 34
	135	87.0	139.3	1.476	36.19	23.19	
	180	35.7	190.6	1.229	36.17	23.16	I_{22V} = 900
	225	-8.1	234.4	1.465	36.03	23.02	
	270	-52.8	279.1	1.358	35.87	22.86	
	315	-94.1	320.4	1.767	36.04	23.03	
2287.5	0	82.6	Ref.	1.065	35.56	22.55	I_{5V} = 102
	45	37.5	45.1	1.656	35.25	22.24	
	90	-12.6	95.2	1.465	35.27	22.26	I_{12V} = 34
	135	-56.0	138.6	1.590	35.29	22.29	
	180	-100.7	183.3	1.302	35.39	22.38	I_{22V} = 780
	225	-148.5	231.1	1.671	35.16	22.15	
	270	165.2	277.4	1.939	35.23	22.22	
	315	129.4	313.2	2.097	35.25	22.24	

*Current measured at 0° phase setting only.

**Only 0° setting is measured on center modules (P/N SK446962-1)

SIZE	CODE IDENT NO	DRAWING NO
A	96214	SKDD302

SCALE | REV | SHEET 3 7

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TABLE I. SPACS II MODULE RECORDED TRANSMITTER DATA
(CONTINUED)

INPUT POWER LEVEL = +14 DBM

FREQUENCY MHZ	COMMANDED PHASE SETTING DEGREES	MEASURED ** PHASE SETTING DEGREES	$\Delta\phi$	INPUT VSWR	POWER OUTPUT DBM	GAIN DB	POWER SUPPLY* CURRENTS MA
2217.5	0	51.9	Ref.	1.427	35.66	21.63	I_{5V} = 102
	45	13.0	38.9	1.624	35.71	21.68	
	90	-48.5	100.4	1.436	35.50	21.47	I_{12V} = 34
	135	-87.3	139.2	1.239	35.45	21.42	
	180	-138.0	189.9	1.285	35.62	21.5[illegible]	I_{22V} = 1030
	225	-175.3	227.2	1.383	35.63	21.59	
	270	138.5	273.4	1.475	35.55	21.51	
	315	101.5	310.4	1.239	35.60	21.57	
2257.5	0	-134.8	Ref.	1.221	36.14	22.13	I_{5V} = 102
	45	-179.5	44.7	1.275	36.01	21.99	
	90	129.8	95.4	1.213	36.04	22.03	I_{12V} = 34
	135	87.9	137.3	1.597	36.16	22.15	
	180	36.1	189.1	1.116	36.12	22.11	I_{22V} = 920
	225	-6.3	231.5	1.443	35.99	21.98	
	270	-51.3	276.5	1.438	35.84	21.83	
	315	-92.0	317.2	1.703	36.05	22.04	
2287.5	0	78.8	Ref.	1.159	35.57	21.57	I_{5V} = 102
	45	35.3	43.5	1.721	35.33	21.33	
	90	-14.8	93.6	1.489	35.33	21.33	I_{12V} = 34
	135	-58.4	137.2	1.538	35.39	21.29	
	180	-107.9	186.7	1.358	35.48	21.48	I_{22V} = 810
	225	-149.9	228.7	1.672	35.23	21.23	
	270	163.5	275.3	1.894	35.34	21.34	
	315	124.8	314.0	1.827	35.49	21.49	

*Current measured at 0° phase setting only.

** Only 0° setting is measured on center modules (P/N SK 446962-1)

SIZE	CODE IDENT NO	DRAWING NO
A	96214	SKDD302
SCALE	REV	SHEET 4

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TABLE II. SPACS II MODULE RECORDED RECEIVER PHASE AND GAIN DATA
(ROOM TEMPERATURE ONLY)

INPUT POWER LEVEL = -40 DBM

FREQUENCY MHZ	COMMANDED PHASE SETTING DEGREES	MEASURED ** PHASE SETTING DEGREES	$\Delta\phi$	INPUT VSWR	GAIN DB	TIME DELAY NSEC	POWER SUPPLY* CURRENTS MA
2030.9	0	-99.6	Ref.	2.149	28.81	13.894	I_{5V} = 100
	45	-141.9	42.3	2.155	28.25	13.527	
	90	-178.9	79.3	2.180	28.05	12.765	I_{12V} = 34
	135	141.9	118.5	2.051	28.54	13.277	
	180	82.6	177.8	2.075	28.85	13.540	
	225	38.6	221.8	2.112	28.60	13.751	
	270	-2.6	263.0	2.203	28.67	13.268	
	315	-43.6	304.0	2.177	29.14	13.806	
2041.9	0	-154.7	Ref.	1.581	30.46	15.004	I_{5V} = 100
	45	164.5	40.8	1.583	29.93	15.189	
	90	130.6	74.7	1.580	29.62	15.316	I_{12V} = 34
	135	89.3	116.0	1.590	30.31	16.569	
	180	29.0	176.3	1.606	30.74	15.436	
	225	-15.8	221.1	1.568	30.80	16.121	
	270	-55.1	260.4	1.556	30.29	15.615	
	315	-98.3	303.6	1.572	30.58	15.693	
2052.9	0	145.9	Ref.	2.444	30.82	13.750	I_{5V} = 100
	45	104.4	41.5	2.351	30.07	13.809	
	90	69.9	76.0	2.233	30.33	13.966	I_{12V} = 34
	135	23.7	122.2	2.599	31.71	14.851	
	180	-32.1	178.0	2.571	31.85	14.490	
	225	-79.7	225.8	2.419	31.16	13.858	
	270	-117.0	262.9	2.185	30.76	13.212	
	315	-160.4	306.3	2.277	31.34	13.506	

*Current measured at 0° phase setting only.
**Only 0° setting is measured on center modules (P/N SK446962-1)

SIZE	CODE IDENT NO	DRAWING NO
A	96214	SKDD302
SCALE	REV	SHEET 5

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TABLE II. SPACS II MODULE RECORDED RECEIVER PHASE AND GAIN DATA (CONTINUED)

INPUT POWER LEVEL = -40 DBM

FREQUENCY MHZ	COMMANDED PHASE SETTING DEGREES	MEASURED ** PHASE SETTING DEGREES	$\Delta\phi$	INPUT VSWR	GAIN DB	TIME DELAY NSEC	POWER SUPPLY* CURRENTS MA
2074.15	0	41.8	Ref.	2.125	30.03	12.671	I_{5V} = 100
	45	1.9	39.9	2.116	29.65	13.234	
	90	-37.7	79.5	2.172	30.46	13.784	I_{12V} = 34
	135	-89.9	131.7	2.341	30.57	12.795	
	180	-138.5	180.3	2.338	30.65	12.304	
	225	179.4	222.4	2.149	29.71	12.385	
	270	142.5	259.3	2.103	29.98	13.209	
	315	94.6	307.2	2.166	30.22	12.777	
2095.4	0	-59.1	Ref.	1.705	29.77	12.750	I_{5V} = 100
	45	-100.7	41.6	1.674	29.55	12.678	
	90	-141.6	82.5	1.562	29.88	12.777	I_{12V} = 34
	135	171.8	129.1	1.658	29.23	12.607	
	180	123.7	177.2	1.684	29.64	11.982	
	225	82.1	218.8	1.759	29.37	11.855	
	270	41.9	259.0	1.710	30.00	12.577	
	315	-4.5	305.4	1.671	29.81	12.468	
2106.4	0	-109.6	Ref.	1.702	30.36	16.782	I_{5V} = 100
	45	-150.9	41.3	1.647	29.74	16.610	
	90	167.8	82.6	1.529	29.83	15.780	I_{12V} = 34
	135	121.9	128.5	1.739	29.81	15.622	
	180	76.3	174.1	1.765	30.26	15.518	
	225	35.2	215.2	1.850	29.87	16.057	
	270	-7.9	258.3	1.773	30.25	15.607	
	315	-53.8	304.2	1.761	30.43	15.607	

*Current measured at 0° phase setting only.

**Only 0° setting is measured on center modules (P/N SK446962-1)

SIZE	CODE IDENT NO	DRAWING NO
A	96214	SKDD302
SCALE	REV	SHEET 6

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TABLE II. SPACS II MODULE RECORDED RECEIVER PHASE AND GAIN DATA (CONTINUED)

INPUT POWER LEVEL = -40 DBM

FREQUENCY MHZ	COMMANDED PHASE SETTING DEGREES	MEASURED** PHASE SETTING DEGREES	$\Delta\phi$	INPUT VSWR	GAIN DB	TIME DELAY NSEC	POWER SUPPLY* CURRENT MA
2117.4	0	-176.0	Ref.	1.146	30.62	19.422	I_{5V} = 100
	45	143.3	40.7	1.153	30.19	18.673	
	90	105.3	78.7	1.174	30.90	19.394	I_{12V} = 34
	135	60.0	124.0	1.344	31.31	21.339	
	180	14.8	169.2	1.286	31.16	19.456	
	225	-28.4	212.4	1.272	31.04	19.336	
	270	-69.7	253.7	1.174	31.44	19.430	
	315	-115.6	299.6	1.195	31.66	20.743	

*Current measured at 0° phase setting only.

**Only 0° setting is measured on center modules (P/N SK446962-1)

SIZE	CODE IDENT NO	DRAWING NO
A	96214	SKDD302

SCALE	REV	SHEET 7	7

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TABLE III. SPACS II MODULE ADDITIONAL RECEIVER TEST DATA (NOISE FIGURE AND COMPRESSION AT ROOM TEMPERATURE ONLY)

FREQUENCY MHZ	RECEIVER NOISE FIGURE DB	RECEIVER NOISE TEMPERATURE °K	RECEIVER OUTPUT 1 DB COMPRESSION POINT DBM	ANTENNA PORT INPUT POWER LEVEL DBM	RECEIVER GAIN DB
2030.9	7.3	1267	+1.85	-23.[illegible]	25.8
2041.9	6.9	1131	+1.7	-24.8	26.5
2052.9	6.7	1067	+0.27	-25.9	26.3
2074.15	6.8	1098	+5.43	-2[illegible].1	33.5
2095.4	5.9	838	+6.83	-27.3	34.1
2106.4	5.6	763	+5.6[illegible]	-2[illegible]	31.7
2117.4	5.7	788	+5.47	-26.0	31.5

TABLE IV. SPACS II MODULE DUPLEX EVALUATION TESTS FOR RECEIVER COMPRESSION

RECEIVE LEVEL (DBM)		TRANSMIT LEVEL (DBM)		FREQUENCY (MHZ)	LOAD VSWR
AT ANTENNA	AT RCV OUTPUT	AT ANTENNA	AT RCV OUTPUT	XMIT/RCV	
-40	-9.0	--	—	OFF/2041.9	1.6:1
-40	-11.0	> +35	+1.0	2217.5/2041.9	1.6:1
-40	-10.0	--	—	OFF/2106.4	1.6:1
-40	-10.0	> +35	-12.0	2287.5/2106.4	1.6:1

TABLE IV. DUPLEX OPERATION CONTINUED, INTERMODULATION PRODUCT EVALUATION (ROOM TEMPERATURE) SUMMARY

		INTERMODULATION FREQUENCY/DBC			
FREQUENCY (MHZ)	LOAD VSWR	F1/IM1	F2/IM2	F3/IM3	F4/IM4
XMIT/RCVR					
2217.5/2041.9	1.05:1	> 30	> 40	> 40	—
2217.5/2041.9	1.6:1	> 30	2390 MHz > 20	> 40	—
2287.5/2106.4	1.05:1	> 40	> 40	> 40	—
2287.5/2106.4	1.6:1	> 30	> 40	> 40	—

SIZE	CODE IDENT NO	DRAWING NO
A	96214	SKDD302
SCALE	REV	SHEET 9

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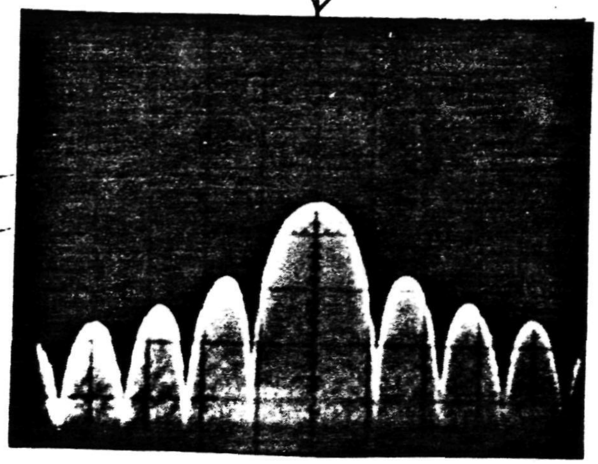
TABLE V. SPACS II MODULE - DUPLEX OPERATION, PULSE MODULATION TESTS, PHOTOGRAPHS

2041.9 MHZ

10 dB/Div.



4.6 MHZ

(A)

TRANSMITTER OFF

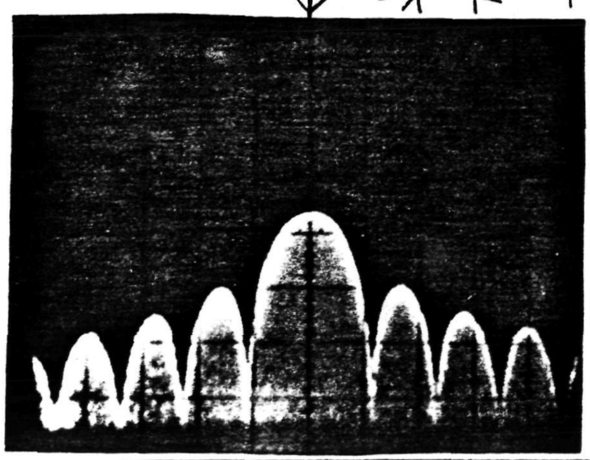
RECEIVE CARRIER
f_R=2041.9 MHZ

INPUT = -40 DBM

OUTPUT = -9.0 DBM

2041.9 MHZ

1 MHz/Div.



(B)

TRANSMITTER ON
f_T=2217.5 MHZ

RECEIVE CARRIER
f_R=2041.9 MHZ

INPUT = -40 DBM

OUTPUT = -11.0 DBM

SIZE	CODE IDENT NO	DRAWING NO
A	96214	SKDD302
SCALE	REV	SHEET 10

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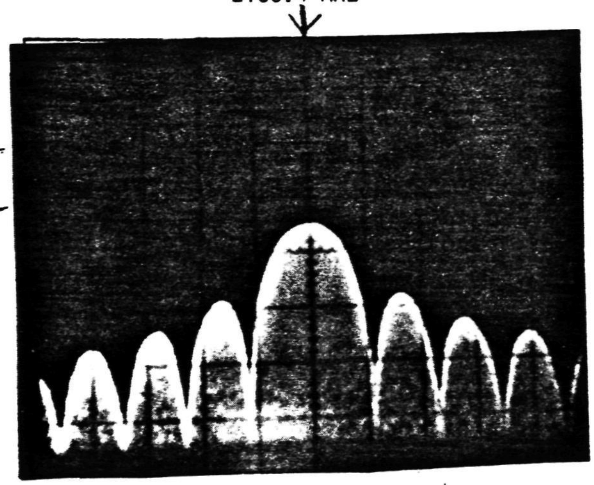
TABLE V. PULSED MODULATION PHOTOGRAPHS CONTINUED

2106.4 MHZ

10 dB/Div.



4.6 MHZ

(C)

TRANSMITTER OFF

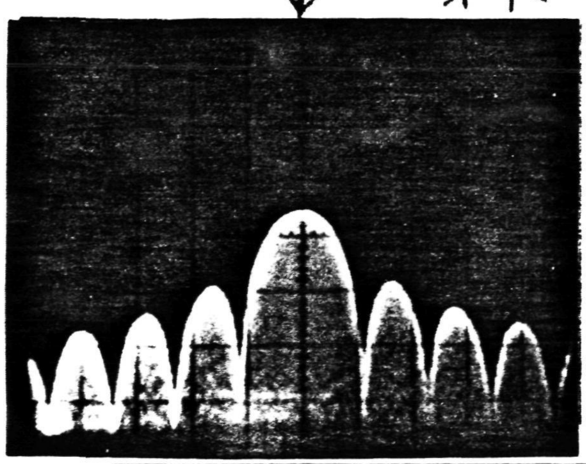
RECEIVE CARRIER
f_R=2106.4 MHZ

INPUT = -40 DBM

OUTPUT = DBM

2106.4 MHZ

1 MHz/Div.



(D)

TRANSMITTER ON
f_T=2287.5 MHZ

RECEIVE CARRIER
f_R=2106.4 MHZ

INPUT = -40 DBM

OUTPUT = DBM

SIZE	CODE IDENT NO	DRAWING NO
A	96214	SKDD302
SCALE	REV	SHEET 11 7

TI-7915C

TABLE VI. SPACS II MODULE SUMMARY OF L-BAND RECEIVER SECTION OF MODULE

FREQUENCY MHZ	ANTENNA CONNECTOR POWER LEVEL DBM	L-BAND INSERTION LOSS DB	CORRESPONDING NOISE TEMPERATURE K°
1600	N.A.	N.A.	N.A.
1775.5			
1803.65			
1831.8			
2000			

SIZE	CODE IDENT NO	DRAWING NO
A	96214	SKDD302

SCALE	REV	SHEET 12

TI-7915C

APPENDIX C

C-i

APPLICATION	
NEXT ASSY	USED ON
SK784010-1	1207
SK446962-1	1207

REVISIONS			
LTR	DESCRIPTION	DATE	APPROVED

SPACS II - TRANSMIT/RECEIVE MICROELECTRONICS MODULE MEASUREMENT DATA SHEETS FOR OUTER MODULES (P/N SK784010-1) AND FOR CENTER MODULES (P/N SK446962-1)

REF: NASA/JSC HOUSTON, TEXAS

CONTRACT: NAS9-14485

A/T Final Data: 7-15-75

MODULE PART NUMBER SK446962-1
(RECORD)

MODULE SERIAL NUMBER 002
(RECORD)

DRD

REV STATUS OF SHEETS	
REV	
SHEET	

UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES TOLERANCES ANGLES ±1° 3 PLACE DECIMAL ±.010 2 PLACE DECIMAL ±.02

IDENTIFYING NUMBERS SHOWN IN PARENTHESES FOR REFERENCE ONLY

INTERPRET DWG IN ACCORDANCE WITH MIL-STD-100

DWN	P. Harkison	DATE 5-?-75
CHK		
ENGR	P. Pazer	5-15-75
QA		
APVD		
CONTR NO		
DESIGN ACTIVITY RELEASE		

TEXAS INSTRUMENTS INCORPORATED
Equipment Group Dallas, Texas

SPACS II-TRANSMIT/RECEIVE MICROELECTRONICS MODULE MEASUREMENT DATA SHEETS

SIZE	CODE IDENT NO	DRAWING NO
A	96214	SKDD302
SCALE		SHEET 1 OF 12

TI-0923-C P1

TABLE I. SPACS II MODULE RECORDED TRANSMITTER DATA
(ROOM TEMPERATURE ONLY)

INPUT POWER LEVEL = +12 DBM

FREQUENCY MHZ	COMMANDED PHASE SETTING DEGREES	MEASURED ** PHASE SETTING DEGREES		INPUT VSWR	POWER OUTPUT DBM	GAIN DB	POWER SUPPLY* CURRENTS MA
2217.5	0	36.1	Ref.	1.215	35.34	23.36	I_{5V} = 0
	45	N.A.	N.A.	N.A.	N.A.	N.A.	
	90						I_{12V} = 43
	135						
	180						
	225						I_{22V} = 950
	270						
	315						
225[illegible].5	0	-119.4	Ref.	1.084	35.15	23.15	I_{5V} = 0
	45	N.A.	N.A.	N.A.	N.A.	N.A	
	90						I_{12V} = 43
	135						
	180						
	225						I_{22V} = 710
	270						
	315						
2287.5	0	108.0	Ref.	1.044	34.84	22.84	I_{5V} = 0
	45	N.A.	N.A.	N.A.	N.A.	N.A.	
	90						I_{12V} = 43
	135						
	180						I_{22V} = 610
	225						
	270						
	315						

*Current measured at 0° phase setting only.

**Only 0° setting is measured on center modules (P/N SK446962-1)

SIZE	CODE IDENT NO	DRAWING NO
A	96214	SKKDD302
SCALE	REV	SHEET 2 2

TI-79150

C-2

TABLE I. SPACS II MODULE RECORDED TRANSMITTER DATA
(CONTINUED

INPUT POWER LEVEL = +13 DBM

FREQUENCY MHZ	COMMANDED PHASE SETTING DEGREES	MEASURED ** PHASE SETTING DEGREES		INPUT VSWR	POWER OUTPUT DBM	GAIN DB	POWER SUPPLY* CURRENTS MA
2217.5	0	37.9	Ref.	1.378	35.23	22.22	I_{5V} = 0
	45	N.A.	N.A	N.A.	N.A.	N.A.	
	90						I_{12V} = 43
	135						
	180						I_{22V} = 960
	225						
	270						
	315						
225[illegible].5	0	-121.5	Ref.	1.215	35.54	22.56	I_{5V} = 0
	45	N.A.	N.A.	N.A.	N.A.	N.A.	
	90						I_{12V} = 43
	135						
	180						I_{22V} = 760
	225						
	270						
	315						
2287.5	0	105.9	Ref.	1.160	34.99	21.99	I_{5V} = 0
	45	N.A.	N.A.	N.A.	N.A.	N.A.	
	90						I_{12V} = 43
	135						
	180						I_{22V} = 650
	225						
	270						
	315						

*Current measured at 0° phase setting only.

**Only 0° setting is measured on center modules (P/N SK446962-1)

SIZE	CODE IDENT NO	DRAWING NO
A	96214	SKDD302
SCALE	REV	SHEET 3

11 7915C

TABLE I. SPACS II MODULE RECORDED TRANSMITTER DATA (CONTINUED)

INPUT POWER LEVEL = +14 DBM

FREQUENCY MHZ	COMMANDED PHASE SETTING DEGREES	MEASURED ** PHASE SETTING DEGREES		INPUT VSWR	POWER OUTPUT DBM	GAIN DB	POWER SUPPLY* CURRENTS MA
2217.5	0	39.7	Ret.	1.541	35.21	21.18	I_{5V} = 0
	45	N.A.	N.A.	N.A.	N.A.	N.A.	
	90						I_{12V} = 43
	135						
	180						I_{22V} = 970
	225						
	270						
	315						
2257.5	0	123.6	Ref.	1.417	35.84	21.83	I_{5V} = 0
	45	N.A.	N.A.	N.A.	N.A.	N.A.	
	90						I_{12V} = 43
	135						
	180						I_{22V} = 800
	225						
	270						
	315						
2287.5	0	104.6	Ref.	1.319	35.05	21.08	I_{5V} = 0
	45	N.A.	N.A.	N.A.	N.A.	N.A.	
	90						I_{12V} = 43
	135						
	180						I_{22V} = 680
	225						
	270						
	315						

*Current measured at 0° phase setting only.

** Only 0° setting is measured on center modules (P/N SK 446962-1)

SIZE	CODE IDENT NO	DRAWING NO
A	96214	SKDD302
SCALE	REV	SHEET 4

TI-7915C

TABLE II. SPACS II MODULE RECORDED RECEIVER PHASE AND GAIN DATA (ROOM TEMPERATURE ONLY)

INPUT POWER LEVEL = -40 DBM

FREQUENCY MHZ	COMMANDED PHASE SETTING DEGREES	MEASURED ** PHASE SETTING DEGREES		INPUT VSWR	GAIN DB	TIME DELAY NSEC	POWER SUPPLY* CURRENTS MA
2030.9	0	-99.9	Ref.	2.282	31.18	13.03	I_{5V} = 0
	45	N.A.	N.A.	N.A.	N.A.	N.A.	I_{12V} = 43
	90						
	135						
	180						
	225						
	270						
	315						
2041.9	0	-151.5	Ref.	3.198	27.26	8.93	I_{5V} = 0
	45	N.A.	N.A.	N.A.	N.A.	N.A.	I_{12V} = 43
	90						
	135						
	180						
	225						
	270						
	315						
2052.9	0	173.1	Ref.	3.826	25.48	8.512	I_{5V} = 0
	45	N.A.	N.A	N.A.	N.A.	N.A.	I_{12V} = 43
	90						
	135						
	180						
	225						
	270						
	315						

*Current measured at 0° phase setting only.
**Only 0° setting is measured on center modules (P/N SK446962-1)

SIZE	CODE IDENT NO	DRAWING NO
A	96214	SKDD302
SCALE	REV	SHEET 5 2

TI-7915C

TABLE II. SPACS II MODULE RECORDED RECEIVER PHASE AND GAIN DATA (CONTINUED)

INPUT POWER LEVEL = -40 DBM

FREQUENCY MHZ	COMMANDED PHASE SETTING DEGREES	MEASURED ** PHASE SETTING DEGREES		INPUT VSWR	GAIN DB	TIME DELAY NSEC	POWER SUPPLY* CURRENTS MA
2074.15	0	98.0	Ref.	3.480	29.7	18.2	I_{5V} = 0
	45	N.A.	N.A.	N.A.	N.A.	N.A.	
	90						I_{12V} = 43
	135						
	180						
	225						
	270						
	315						
2095.4	0	-55.1	Ref.	8.779	32.06	16.75	I_{5V} = 0
	45	N.A.	N.A.	N.A.	N.A.	N.A.	
	90						I_{12V} = 43
	135						
	180						
	225						
	270						
	315						
2106.4	0	-121.4	Ref.	8.640	29.18	16.63	I_{5V} = 0
	45	N.A.	N.A.	N.A.	N.A.	N.A.	
	90						I_{12V} = 43
	135						
	180						
	225						
	270						
	315						

*Current measured at 0° phase setting only.

**Only 0° setting is measured on center modules (P/N SK446962-1)

SIZE	CODE IDENT NO	DRAWING NO
A	96214	SKDD302
SCALE	REV	SHEET 6

TI 7915C

TABLE II. SPACS II MODULE RECORDED RECEIVER PHASE AND GAIN DATA (CONTINUED)

INPUT POWER LEVEL = -40 DBM

FREQUENCY MHZ	COMMANDED PHASE SETTING DEGREES	MEASURED** PHASE SETTING DEGREES		INPUT VSWR	GAIN DB	TIME DELAY NSEC	POWER SUPPLY* CURRENT MA
2117.4	0	172.7	Ref.	2.634	26.54	18.742	I_{5V} = 0
	45	N.A.	N.A.	N.A.	N.A.	N.A.	I_{12V} = 43
	90						
	135						
	180						
	225						
	270						
	315						

*Current measured at 0° phase setting only.

**Only 0° setting is measured on center modules (P/N SK446962-1)

SIZE	CODE IDENT NO	DRAWING NO
A	96214	SKDD302
SCALE	REV	SHEET 7

TI-7915C

TABLE III. SPACS II MODULE ADDITIONAL RECEIVER TEST DATA (NOISE FIGURE AND COMPRESSION AT ROOM TEMPERATURE ONLY)

FREQUENCY MHZ	RECEIVER NOISE FIGURE DB	RECEIVER NOISE TEMPERATURE °K	RECEIVER OUTPUT 1 DB COMPRESSION POINT DBM	ANTENNA PORT INPUT POWER LEVEL DBM	RECEIVER GAIN DB
2030.9	6.1	892	+7.75	-23.2[illegible]	30.99
2041.9	6.3	948	+7.51	-19.87	27.38
2052.9	5.9	838	+9.07	-19.34	28.46
2074.15	5.9	835	+5.77	-21.23	30.00
2095.4	5.8	813	+11.07	-19.75	30.82
2106.4	6.0	865	+8.84	-20.24	29.08
2117.4	6.8	1098	+8.83	-17.86	26.69

TABLE IV. SPACS II MODULE DUPLEX EVALUATION TESTS FOR RECEIVER COMPRESSION

RECEIVE LEVEL (DBM)		TRANSMIT LEVEL (DBM)		FREQUENCY (MHZ)	LOAD VSWR
AT ANTENNA	AT RCV OUTPUT	AT ANTENNA	AT RCV OUTPUT	XMIT/RCV	
-40	-12.0	--	—	OFF/2041.9	1.6:1
-40	-13.0	> +35	+10.0	2217.5/2041.9	1.6:1
-40	-9.5	--	—	OFF/2106.4	1.6:1
-40	-10.0	> +35	-5.5	2287.5/2106.4	1.6:1

SIZE	CODE IDENT NO	DRAWING NO
A	96214	SKDD302
SCALE	REV	SHEET 8 2

TI-7915C

TABLE IV. DUPLEX OPERATION CONTINUED, INTERMODULATION PRODUCT EVALUATION (ROOM TEMPERATURE) SUMMARY

		INTERMODULATION FREQUENCY/DBC			
FREQUENCY (MHZ)	LOAD VSWR	F1/IM1	F2/IM2	F3/IM3	F4/IM4
XMIT/RCVR					
2217.5/2041.9	1.05:1	>30	>40	>40	—
2217.5/2041.9	1.6:1	>30	2390 MHz >20	>40	—
2287.5/2106.4	1.05:1	>40	>40	>40	—
2287.5/2106.4	1.6:1	>30	>40	>40	—

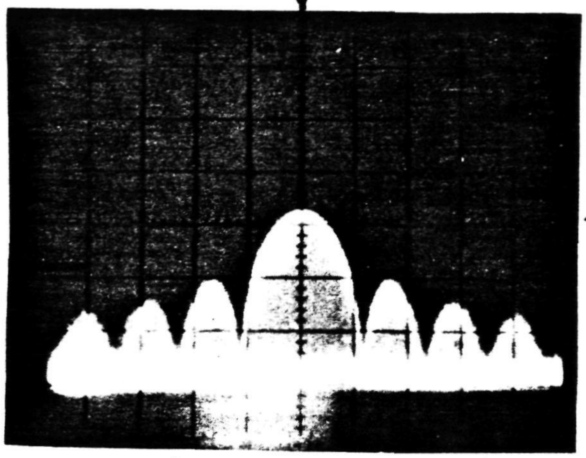
SIZE	CODE IDENT NO	DRAWING NO
A	96214	SKDD302
SCALE	REV	SHEET 9 2

TI-7915C

TABLE V. SPACS II MODULE - DUPLEX OPERATION, PULSE MODULATION TESTS, PHOTOGRAPHS

2041.9 MHZ

10dB/Div



4.6 MHZ

(A)

TRANSMITTER OFF

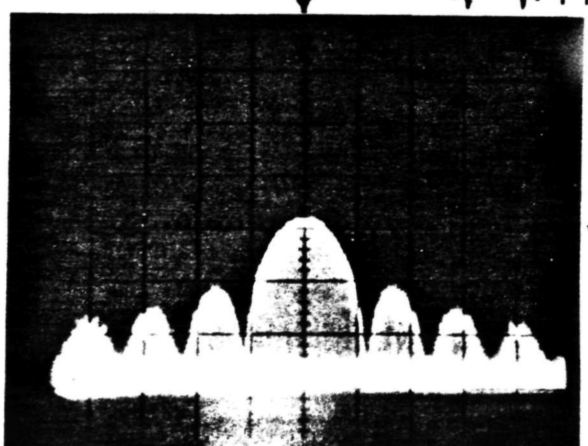
RECEIVE CARRIER
f_R=2041.9 MHZ

INPUT = -40 DBM

OUTPUT = -12.0 DBM

2041.9 MHZ

1 MHz/Div.



(B)

TRANSMITTER ON
f_T=2217.5 MHZ

RECEIVE CARRIER
f_R=2041.9 MHZ

INPUT = -40 DBM

OUTPUT = -13.0 DBM

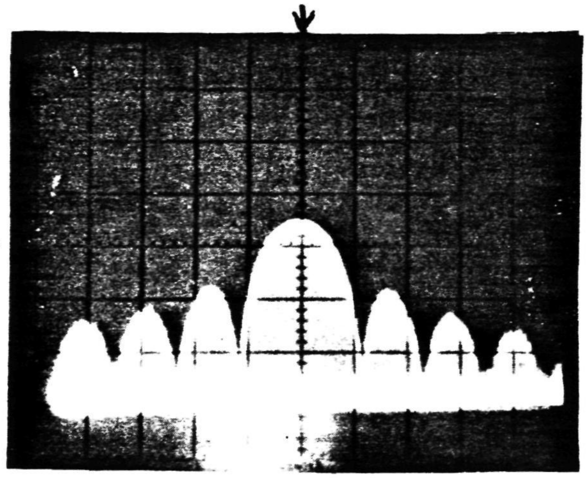
SIZE	CODE IDENT NO	DRAWING NO
A	96214	SKDD302 C-10
SCALE	REV	SHEET 10 2

TI-7915C

TABLE V. PULSED MODULATION PHOTOGRAPHS CONTINUED

2106.4 MHZ

10 dB/div.



4.6 MHZ

(C)

TRANSMITTER OFF

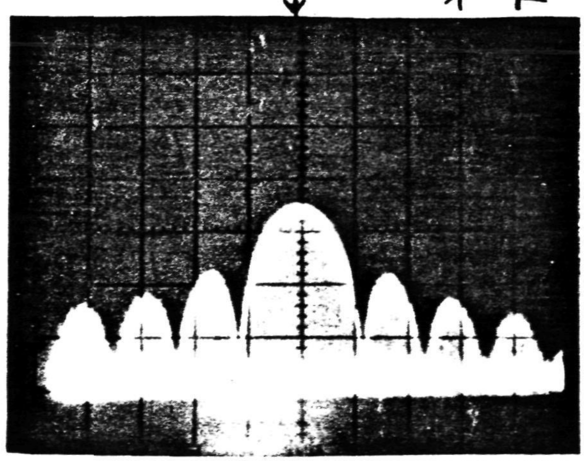
RECEIVE CARRIER
f_R=2106.4 MHZ

INPUT = -40 DBM

OUTPUT = -9.5 DBM

2106.4 MHZ

1 MHz/div



(D)

TRANSMITTER ON
f_T=2287.5 MHZ

RECEIVE CARRIER
f_R=2106.4 MHZ

INPUT = -40 DBM

OUTPUT = -10.0 DBM

SIZE	CODE IDENT NO	DRAWING NO
A	96214	SKDD302 C-11
SCALE	REV	SHEET 11 2

TI-7915C

TABLE VI. SPACS II MODULE SUMMARY OF L-BAND RECEIVER SECTION OF MODULE

FREQUENCY MHZ	ANTENNA CONNECTOR POWER LEVEL DBM	L-BAND INSERTION LOSS DB	CORRESPONDING NOISE TEMPERATURE K°
1600	-20	-8.78	1900
1775.5	-15	-3.75	398
1803.65	-15	-3.29	329
1831.8	-20	-3.39	348
2000	-[illegible]	-11.85	4150

SIZE	CODE IDENT NO	DRAWING NO
A	96214	SKDD302 C-12

SCALE | REV | SHEET 12 2

TI-7915C

APPENDIX D

D-i

A

APPLICATION		REVISIONS			
NEXT ASSY	USED ON	LTR	DESCRIPTION	DATE	APPROVED
	1207				

SPACS II -

DC & LOGIC MANIFOLD ELECTRICAL/MECHANICAL

TEST PROCEDURE AND MODULE

COMPATIBILITY TESTS

P/N SK446961

REF: NASA/JSC Houston, Texas

Contract: NAS9-14485

REV	
SHEET	
REV STATUS OF SHEETS	REV
	SHEET

UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES TOLERANCES ANGLES ± 1° 3 PLACE DECIMAL ± .010 2 PLACE DECIMAL ± .02	DWN D. Dolezal DATE 6-13-75	TEXAS INSTRUMENTS INCORPORATED Equipment Group Dallas, Texas
	CHK	
IDENTIFYING NUMBERS SHOWN IN PARENTHESES FOR REFERENCE ONLY	ENGR D. Dolezal 6-13-75	DC & LOGIC MANIFOLD ELECTRICAL/MECHANICAL TEST PROCEDURE AND MODULE COMPATIBILITY TESTS.
	QA	
INTERPRET DWG IN ACCORDANCE WITH MIL-STD-100	APVD	
	CONTR NO	SIZE A · CODE IDENT NO 96214 · DRAWING NO SKDD501
	DESIGN ACTIVITY RELEASE	
		SCALE · SHEET 1 of 2

TI-9923-C

SPACS II -

DC & LOGIC MANIFOLD TESTING

1.0 INTRODUCTION

The purpose of this document is to describe the various electrical and mechanical tests that will be performed on the DC and logic manifold.

2.0 DC MANIFOLD ELECTRICAL TESTS

Continuity tests will be performed on the DC manifold (P/N SK446941) to insure that there are no shorted or open pins and that the DC manifold conforms to the requirements called out in Paragraphs 1.2.2, 3.3, and 3.7.4 of Contract NAS9-14485 (Statement of Work).

3.0 DC MANIFOLD COMPATIBILITY CHECKS

The DC manifold will be integrated into the antenna array housing to insure that it is mechanically compatible with the array hardware. In addition, the array wiring harness P/N SK446985 will be plugged into the DC manifold connectors. The appropriate electrical signals will be applied to the array subsystem connector (SK446943) and the DC manifold will be checked with a digital voltmeter and oscilloscope to insure that these input signals are distributed properly to the manifold module connectors (SK446981 and SK 446982).

A further mechanical compatibility check will be made to insure that the T/R modules will plug into the manifold connectors while it is mounted in the antenna array housing (this includes the RF manifolds).

SIZE	CODE IDENT NO	DRAWING NO
A	96214	SKDD501
SCALE	REV	SHEET 2

TI-7915C

APPENDIX E

E-i

A

APPLICATION		REVISIONS			
NEXT ASSY	USED ON	LTR	DESCRIPTION	DATE	APPROVED
	1207				

SPACS II - BREADBOARD SEVEN ELEMENT
PHASED ARRAY ANTENNA TEST PROCEDURE
AND DATA SHEETS

REF: NASA/JSC (HOUSTON,TEXAS)

CONTRACT: NAS9-14485

Final Data
Taken 8/7/75

DRD

REV	
SHEET	
REV STATUS OF SHEETS	REV
	SHEET

UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES TOLERANCES ANGLES ±1° 3 PLACE DECIMAL ±.010 2 PLACE DECIMAL ±.02	DWN D. HARDISON DATE 6/16/75	TEXAS INSTRUMENTS INCORPORATED Equipment Group Dallas, Texas
	CHK	
IDENTIFYING NUMBERS SHOWN IN PARENTHESES FOR REFERENCE ONLY	ENGR D. Dezer 6/16/75	SPACS II-BREADBOARD SEVEN ELEMENT PHASED ARRAY ANTENNA TEST PROCEDURE AND DATA SHEETS
	QA	
INTERPRET DWG IN ACCORDANCE WITH MIL-STD-100	APVD	
	CONTR NO	SIZE A · CODE IDENT NO 96214 · DRAWING NO SKDD401
	DESIGN ACTIVITY RELEASE	
		SCALE · SHEET 1 OF 18

TI-9923-C
P1

SPACS II TESTING

I. INTRODUCTION

The purpose of this document is to describe the test procedure for the SPACS II seven element phased array antenna subsystem. This subsystem is composed of a seven element square spiral antenna array, RF (transmit and receive) manifolds, DC and logic manifold, and seven T/R micro-electronics modules. Both transmit and receive characteristics of this subsystem will be measured. A picture of the array is shown in Figure 1. The array is mounted in a large curved ground plane shown in Figure 2.

II. TRANSMIT EIRP AND PATTERN TESTS

For purposes of obtaining transmit antenna EIRP and patterns the equipment will be arranged as shown in the block diagram in Figure 3. Data will be taken using a rotating linearly polarized receiving horn in order to display axial ratio. Principal plane patterns for the assembled array will be taken about 0° (boresight), 35°, and 70° in the horizontal axis; and 0° (boresight), 25°, and 50° in the vertical plane. Reference gain levels will be included on these patterns. The array will be set to the appropriate scan angles by switching the SPACS control box and manually stepping through each of the module transmit phase shifters sequentially.

The module phase shifter positions for the measured array patterns will be as shown in Table 1. Table 2 give the planes of cut and frequencies of the patterns to be measured. The geometry defining ϕ is shown in Figure 4. The patterns will allow one to obtain sidelobe, beamwidth, and axial ratio information.

In order to measure the transmit EIRP, the standard gain horn shown in Figure 3 is used for comparison (substitution method). The RF switch will be calibrated on an HP network analyzer over the SPACS II frequency band. Since the standard gain horn (SGH) will be mounted on the rear of the ground plane, one need only switch the RF and rotate the positioner 180° in order to obtain a comparison. The input power into the SPACS II array and standard gain horn will be the same, +23.5 dBm over the transmit frequency band. Since the gain of the SPACS II array is greater than the SGH, linearity in the RF and IF receiving sections will be checked while transmitting with the SPACS II array. Table 3 gives the transmit frequencies at which EIRP measurements will be

made. Only on-boresight EIRP data is required by the contract. EIRP values at the additional scan angles are shown for information purposes only.

Since we will know the input power to the array and since Table 3 includes all the necessary data to calculate the array gain, the transmit EIRP can also be easily determined. In this instance, the gain is referred to a matched circularly polarized isotropic source. The G_{cp} gain is related to the axial ratio and linear gain via:

$$G_{cp} = G_{linear} + b$$

where $G_{linear} = G_{SGH} + \Delta dB$

$b = 10 \log (1+r^2)$

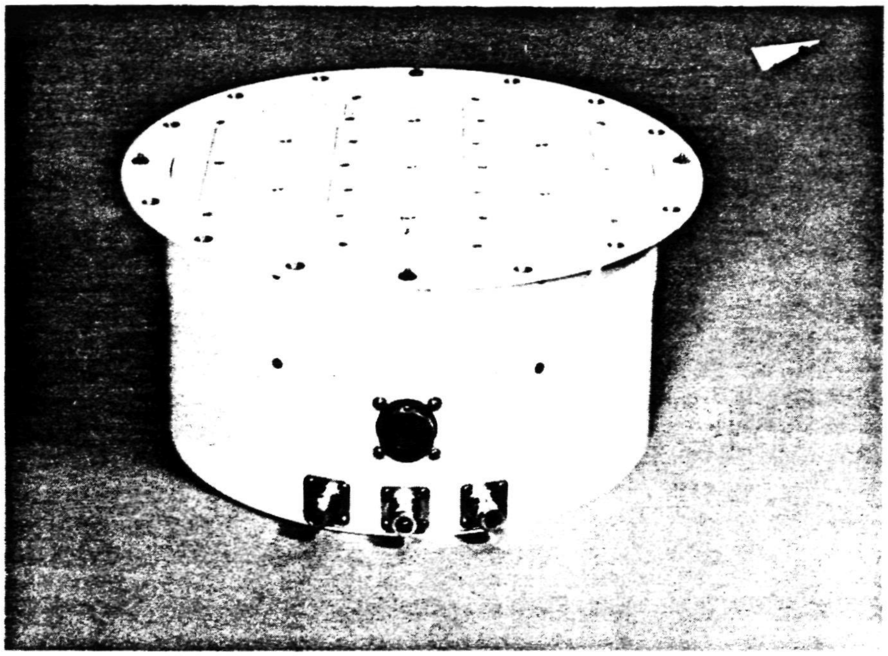
and $r = 10^{-a/20}$

a = axial ratio in dB

Here G_{linear} is the gain of the maximum envelope of the rotating linear polarization; and a is the difference between maximum and minimum envelopes. The terminology is defined more clearly in Figure 5. Note that in addition to gain versus frequency in Table 3, we also obtain axial ratio versus frequency.

III. RECEIVE GAIN AND PATTERN TESTS

For purposes of obtaining receive antenna patterns and gain, the equipment will be arranged as shown in the block diagram of Figure 6. Data will be taken using a rotating linearly polarized transmitting horn in order to display axial ratio. Principal plane patterns will be taken about 0° (boresight), 35°, and 70° in the horizontal axis; and 0° (boresight), 25°, and 50° in the vertical plane. Reference gain levels will be included on these patterns. The array will be set to the appropriate scan angles by switching the SPACS control box and manually stepping through each of the module receive phase shifters sequentially. The module phase receive shifter positions for the measured array patterns will be the same as shown in Table 1. Table 4 gives the planes of cut and frequencies of the patterns to be measured. Care must be taken to insure that the transmitting horn is limited in radiated power so that the SPACS II array is operated in its receiver linear gain region. This will be checked before tests are made. Similar gain and axial ratio calculations can be made for the receiver as was made for the transmitter. Table 5 gives the receive frequencies at which measurements will be made for informational purposes only.



1207-19

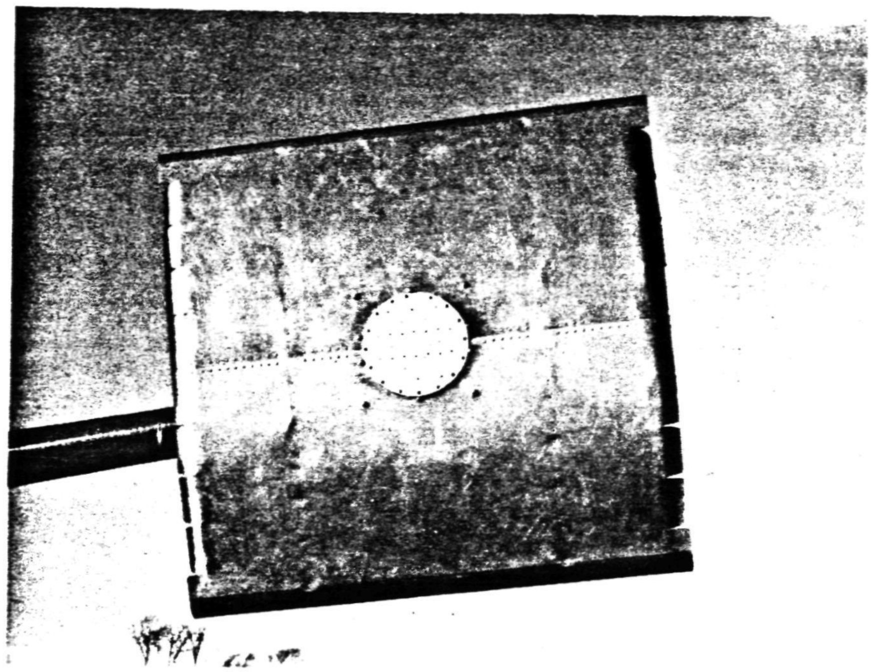
TEXAS INSTRUMENTS

FIGURE 1. SPACS II ANTENNA ARRAY SUBSYSTEM

SIZE	CODE IDENT NO	DRAWING NO	
A	96214	SKDD401	
SCALE	REV		SHEET 4

TI-7915C

E-4



1207-14

TEXAS INSTRUMENTS

FIGURE 2. SPACS II ARRAY IN GROUND PLANE TEST FIXTURE

SIZE	CODE IDENT NO	DRAWING NO
A	96214	SKDD401

SCALE	REV	SHEET 5

TI-7915C

E-5

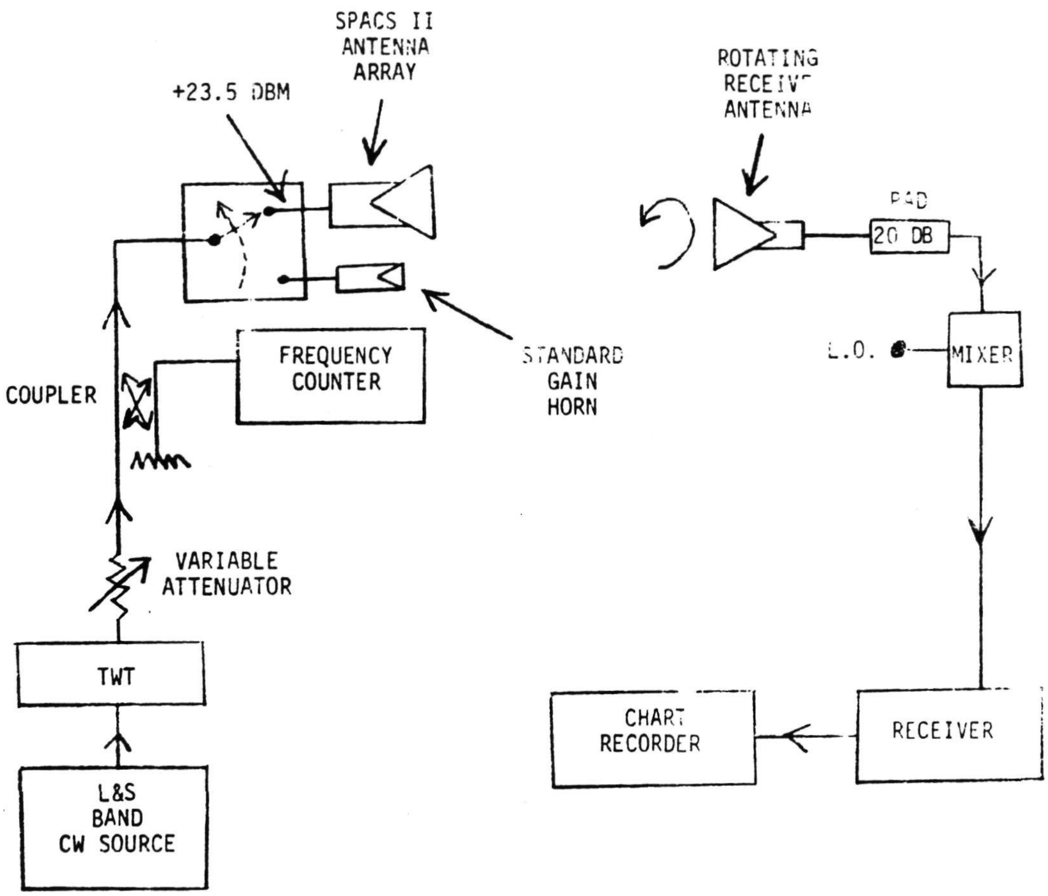


FIGURE 3. SPACS II ANTENNA ARRAY-TRANSMIT EIRP AND ANTENNA PATTERN MEASUREMENT

SIZE	CODE IDENT NO	DRAWING NO
A	96214	SKDD401
SCALE	REV	SHEET 6

TI-7915C

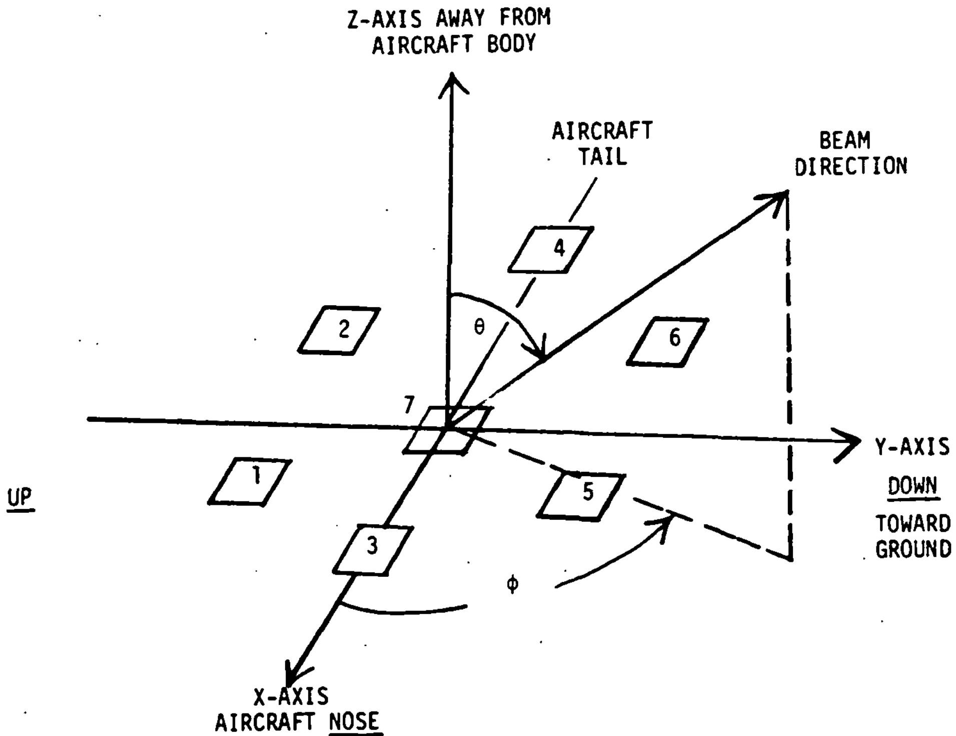


FIGURE 4. SPACS II ANTENNA ARRAY STEERING GEOMETRY AND COORDINATES

SIZE	CODE IDENT NO	DRAWING NO
A	96214	SKDD401
SCALE	REV	SHEET 7

TI-7919C

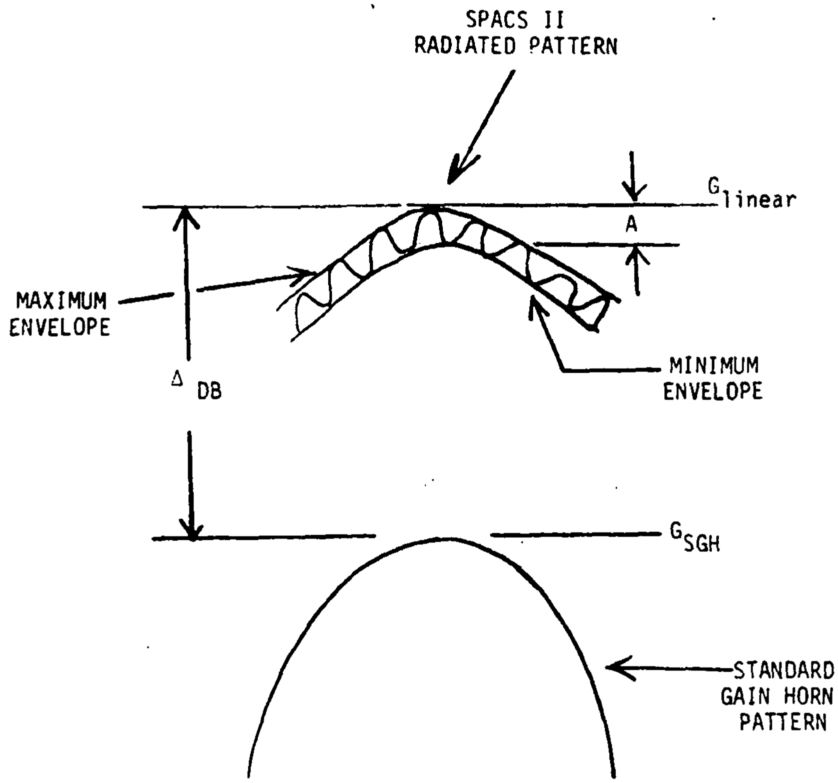


FIGURE 5. SPACS II ANTENNA ARRAY-EIRP/GAIN MEASUREMENT TERMINOLOGY

SIZE	CODE IDENT NO	DRAWING NO
A	96214	SKDD401
SCALE	REV	SHEET 8

TI-7915C

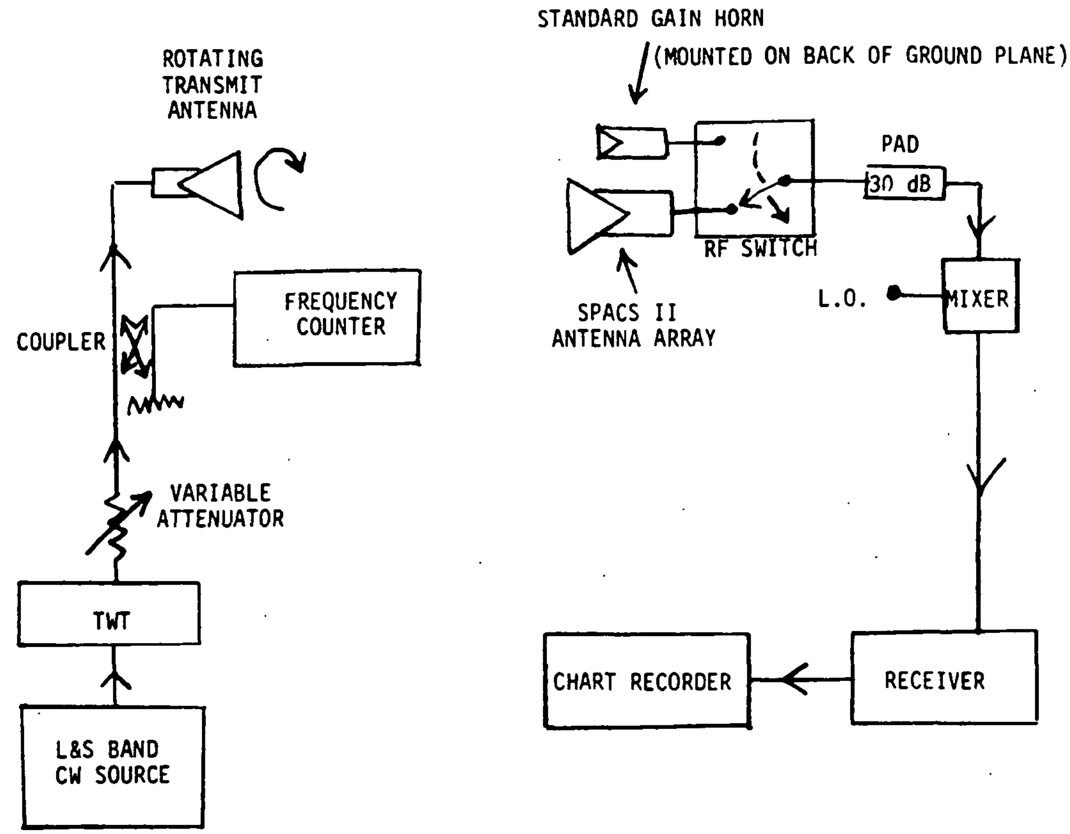
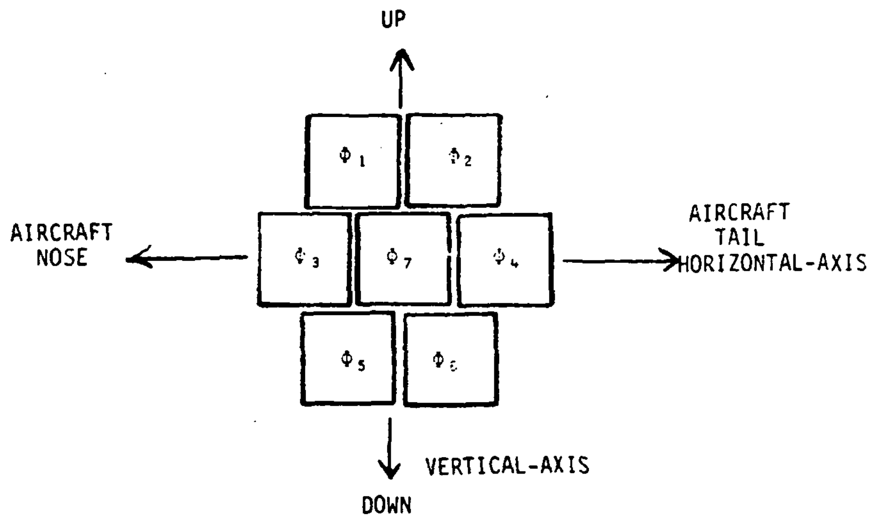


FIGURE 6. SPACS II ANTENNA ARRAY-RECEIVE GAIN AND ANTENNA PATTERN MEASUREMENT

SIZE	CODE IDENT NO	DRAWING NO
A	96214	SKD0401
SCALE	REV	SHEET 9

TI-7915C

TABLE 1. MODULE PHASE SHIFTER SETTINGS FOR REQUIRED ANTENNA SCAN MEASUREMENTS



ARRAY		COMMANDED MODULE PHASE SHIFTER POSITIONS						
SCAN POSITION	PEAK OF BEAM SCAN ANGLE	Φ_1	Φ_2	Φ_3	Φ_4	Φ_5	Φ_6	Φ_7
A.	HORIZONTAL PLANE	-	-	-	-	-	-	-
1	0°	0°	0°	0°	0°	0°	0°	0°
2	25°	45°	315°	90°	270°	45°	315°	0°
3	48°	90°	270°	180°	180°	90°	270°	0°
B.	VERTICAL PLANE	-	-	-	-	-	-	-
1	0°	0°	0°	0°	0°	0°	0°	0°
2	25°	90°	90°	0°	0°	270°	270°	0°
3	38°	135°	135°	0°	0°	225°	225°	0°

SIZE	CODE IDENT NO	DRAWING NO
A	96214	SKDD401
SCALE	REV	SHEET 10

TI-7815C

E-10

TABLE 2. SPACS II ANTENNA ARRAY-FREQUENCIES AND PLANES OF CUT FOR ANTENNA TRANSMIT PATTERN MEASUREMENTS

ARRAY SCAN POSITION	ARRAY PEAK OF BEAM SCAN ANGLE	FREQUENCY (MHZ)	ϕ PLANE OF CUT (DEGREES)	MEASUREMENT SCAN ANGLE (DEGREES)
A.	HORIZONTAL PLANE	-	-	-
1	0°	2217.5 2287.5	0°	ON-BORESIGHT ON-BORESIGHT
2	25°	2217.5 2287.5		35 35
3	48°	2217.5 2287.5		70 70
B.	VERTICAL PLANE	-	-	
1	0°	2217.5 2287.5	90°	ON-BORESIGHT ON-BORESIGHT
2	25°	2217.5 2287.5		25 25
3.	38°	2217.5 2287.5		50 50

SIZE	CODE IDENT NO	DRAWING NO
A	96214	SKD0401

SCALE	REV	SHEET 11

TI-7815C

TABLE 3. SPACS II ANTENNA ARRAY-EIRP MEASUREMENTS AT TRANSMIT FREQUENCIES*

ARRAY SCAN POSITION	ARRAY PEAK OF BEAM SCAN ANGLE	F (MHZ)	ϕ PLANE OF CUT (DEGREES)	SCAN ANGLE FOR EIRP (DEGREES)	G_{SGH} (DB)	Δ_{DB}	A (DB)	B (DB)	G_{CP} (DB)	EIRP DBW
A.	Azimuth HORIZONTAL PLANE	-	-	-	-	-	-	-	-	-
1	0°	2217.5 2287.5	0°	BORESIGHT BORESIGHT	16.28 16.46	10.8 10.0	0.2 0.2	2.9 2.9	30.0 29.4	23.5 22.9
2	25°	2217.5 2287.5		35 35	16.28 16.46	9.2 9.0	0.8 0.1	2.65 2.95	28.1 28.4	21.6 21.9
3	48°	2217.5 2287.5		70 70	16.28 16.46	6.5 5.6	4.7 3.2	1.25 1.70	24.0 23.8	17.5 17.3
B.	Roll VERTICAL PLANE	-	-	-	-	-	-	-	-	-
1	0°	2217.5 2287.5	90°	BORESIGHT BORESIGHT	16.28 16.46	11.0 10.0	0.2 0.4	2.9 2.8	30.2 29.3	23.7 22.8
2	25°	2217.5 2287.5		25 25	16.28 16.46	9.0 9.4	0.1 0.5	2.95 2.75	28.2 28.6	21.7 22.1
3	38°	2217.5 2287.5		50 50	16.28 16.46	7.5 7.1	0.7 0.8	2.7 2.65	26.5 26.2	20.0 19.7

*NOTE: INPUT POWER TO ARRAY IS -6.5 DBW (+23.5 dBm)

SIZE	CODE IDENT NO	DRAWING NO
A	96214	SKDD401
SCALE	REV	SHEET 12

TI-7915C

TABLE 4. SPACS II ANTENNA ARRAY-FREQUENCIES AND PLANES OF CUT FOR ANTENNA RECEIVE PATTERN MEASUREMENTS

ARRAY SCAN POSITION	ARRAY PEAK OF BEAM SCAN ANGLE	F (MHZ)	ϕ PLANE OF CUT (DEGREES)	MEASUREMENT SCAN ANGLE (DEGREES)
A.	HORIZONTAL PLANE	-	-	-
1	0°	2041.9 2106.4	0°	ON-BORESIGHT ON-BORESIGHT
2	25°	2041.9 2106.4	↓	35 35
3	48°	2041.9 2106.4	↓	70 70
B.	VERTICAL PLANE	-	-	-
1	0°	2041.9 2106.4	90°	ON-BORESIGHT ON-BORESIGHT
2	25°	2041.9 2106.4	↓	25 25
3	38°	2041.9 2106.4	↓	50 50

SIZE	CODE IDENT NO	DRAWING NO
A	96214	SKDD401
SCALE	REV	SHEET 13

T1-7915C

TABLE 5. SPACS II ANTENNA ARRAY-GAIN MEASUREMENTS AT RECEIVE FREQUENCIES*

ARRAY SCAN POSITION	ARRAY PEAK OF BEAM SCAN ANGLE	F (MHZ)	PLANE OF CUT (DEGREES)	SCAN ANGLE FOR G_{CP} (DEGREES)	G_{SGH} (DB)	Δ_{DB}	A (DB)	B (DB)	G_{CP} (DB)	RCVR LINEAR OUTPUT LEVEL (DBM)
A.	Azimuth HORIZONTAL PLANE	-	-	-	-	-	-	-	-	-
1	0°	2041.9	0°	BORESIGHT	15.76	21.2	0.2	2.9	39.9	+10.0
		2106.4		BORESIGHT	15.93	19.7	0.1	2.95	38.6	+12.1
2	25°	2041.9		35	15.76	19.8	0.4	2.8	38.4	+9.8
		2106.4		35	15.93	18.4	0.4	2.8	37.1	+11.5
3	48°	2041.9		70	15.76	17.8	8.0	0.65	34.2	+9.6
		2106.4		70	15.93	16.2	6.0	1.0	33.1	+11.1
B.	Roll VERTICAL PLANE	-	-	-	-	-	-	-	-	-
1	0°	2041.9	90°	BORESIGHT	15.76	21.0	0.1	2.95	39.7	+10.3
		2106.4		BORESIGHT	15.93	19.7	0.8	2.65	38.3	+12.2
2	25°	2041.9		25	15.76	20.0	0.4	2.8	38.6	+9.5
		2106.4		25	15.93	19.1	0.2	2.9	37.9	+11.0
3	38°	2041.9		50	15.76	17.8	0.8	2.65	36.2	+10.0
		2106.4		50	15.93	16.0	0.8	2.65	34.6	+11.5

*NOTE: LINEAR RCVR OUTPUT IS FOR LESS THAN 1 DB RECEIVER GAIN COMPRESSION

SIZE	CODE IDENT NO	DRAWING NO
A	96214	SKDD401
SCALE	REV	SHEET 14

TI-7915C

APPENDIX

SIZE	CODE IDENT NO	DRAWING NO
A	96214	SKDD401

SCALE	REV	SHEET 15

TI-7915C

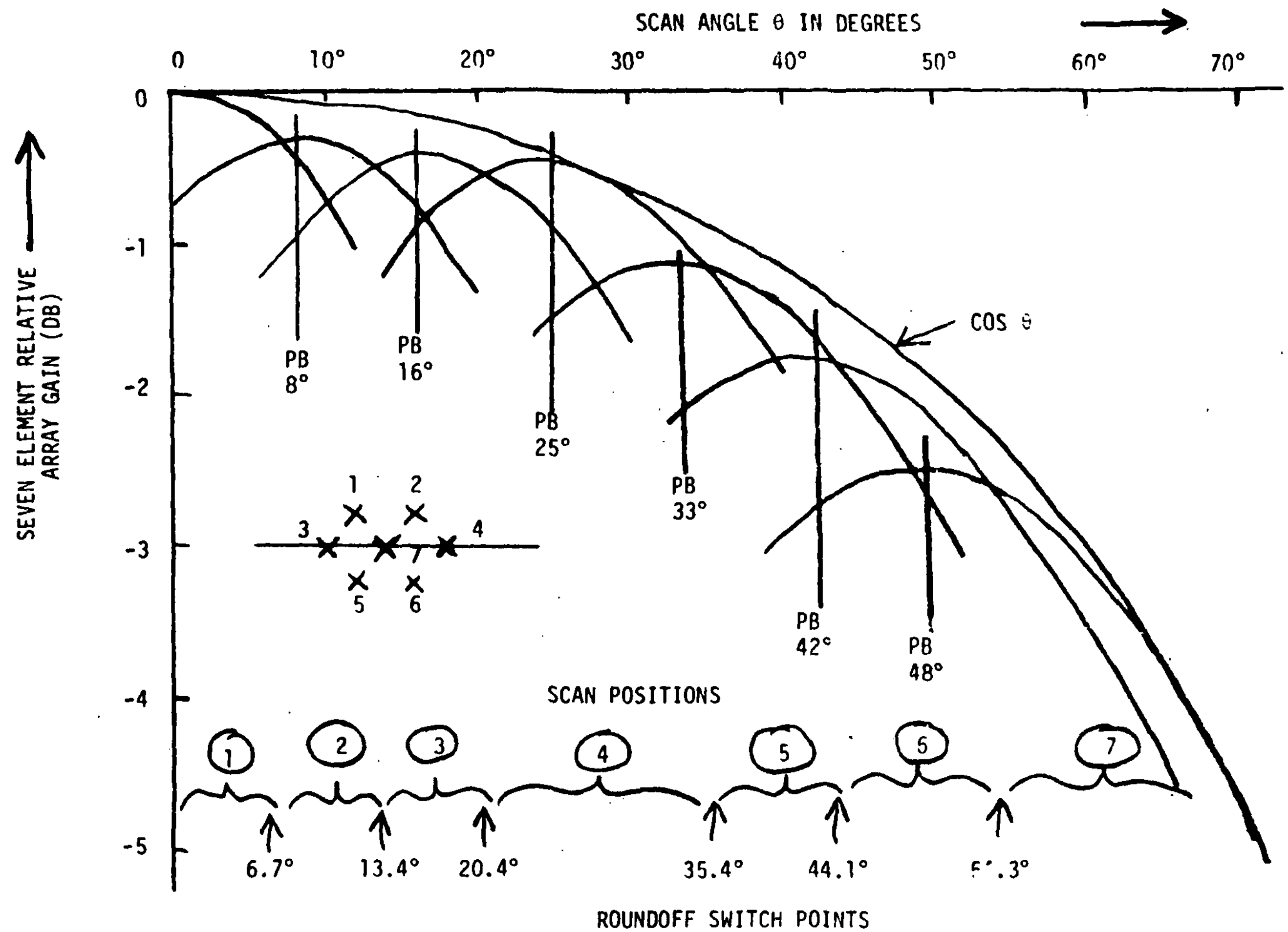


FIGURE A-1. SPACS II ANTENNA ARRAY BEAM SCAN POSITIONS IN $\phi = 0°$ (HORIZONTAL) PLANE FOR 3 BIT PHASE SHIFTER, $S_\lambda = 0.539$

SIZE	CODE IDENT NO	DRAWING NO
A	96214	SKDD401
SCALE	REV	SHEET 16

TI-7915C

E-16

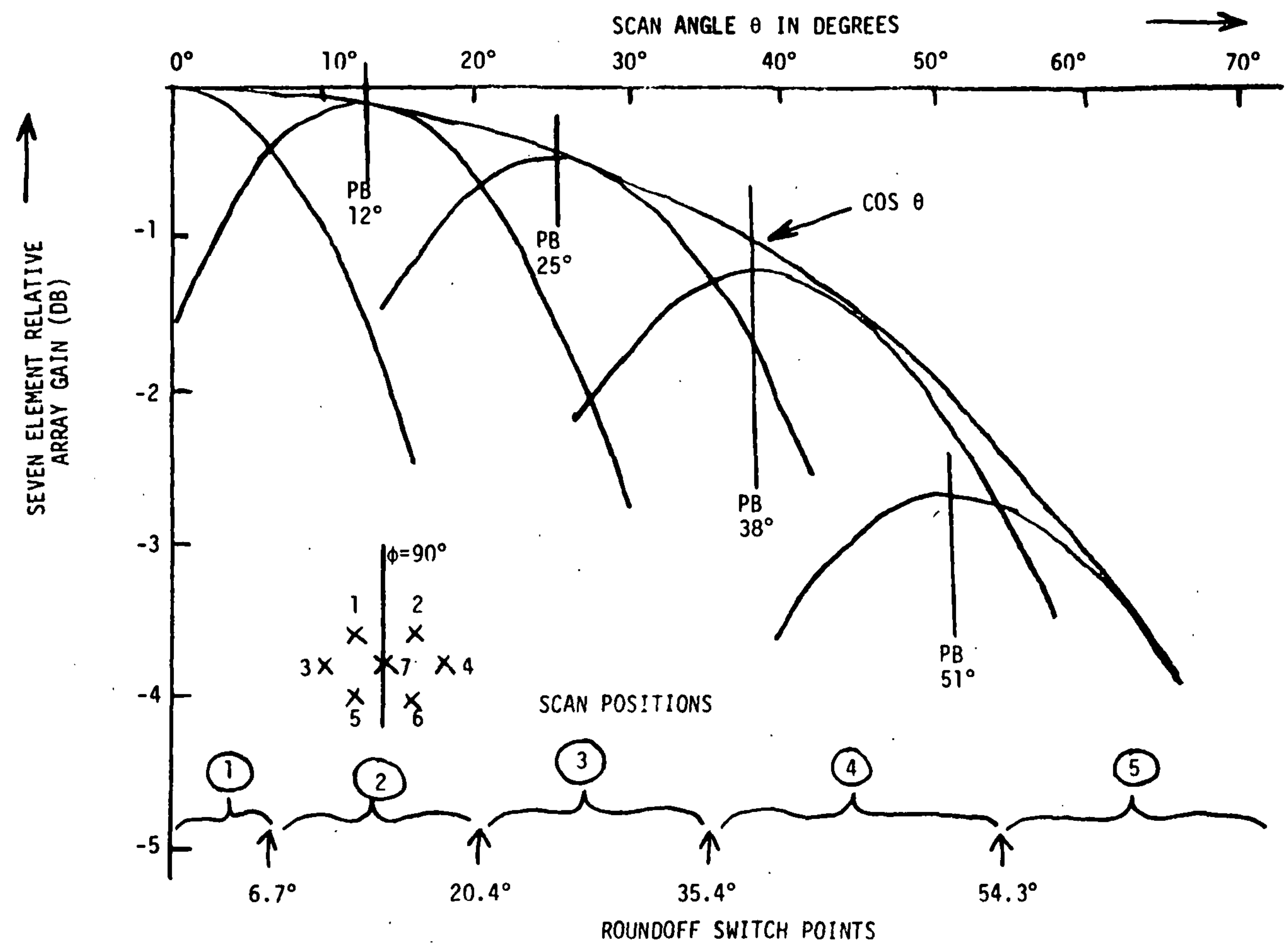


FIGURE A-2. SPACS II ANTENNA ARRAY BEAM SCAN POSITIONS IN $\phi=90°$ (VERTICAL) PLANE FOR 3 BIT PHASE SHIFTER, $S_\lambda = 0.539$

SIZE	CODE IDENT NO	DRAWING NO
A	96214	SKDD401 E-17
SCALE	REV	SHEET 17

TI-7915C

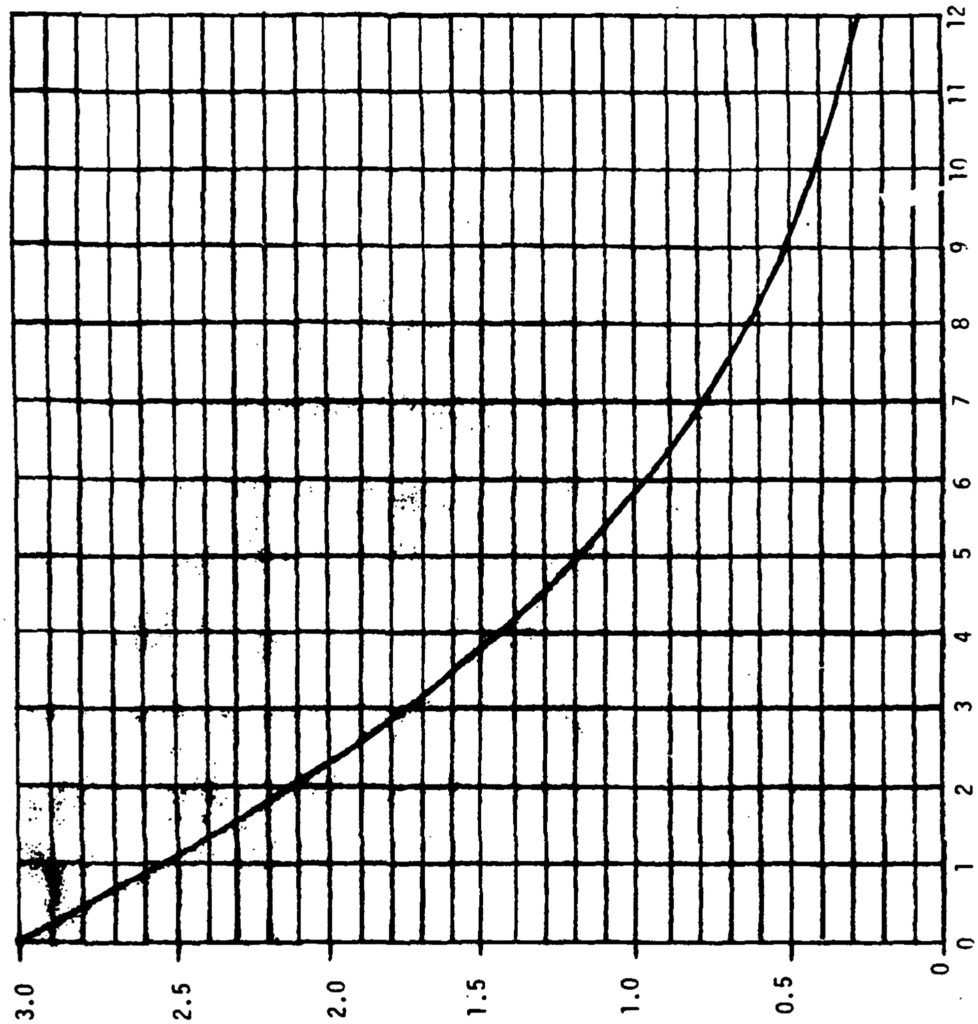


FIGURE A-3. MATCHED POLARIZATION GAIN CORRECTION FACTOR

SIZE	CODE IDENT NO	DRAWING NO
A	96214	SKDD401 E-18
SCALE	REV	SHEET 18

TI-7915C